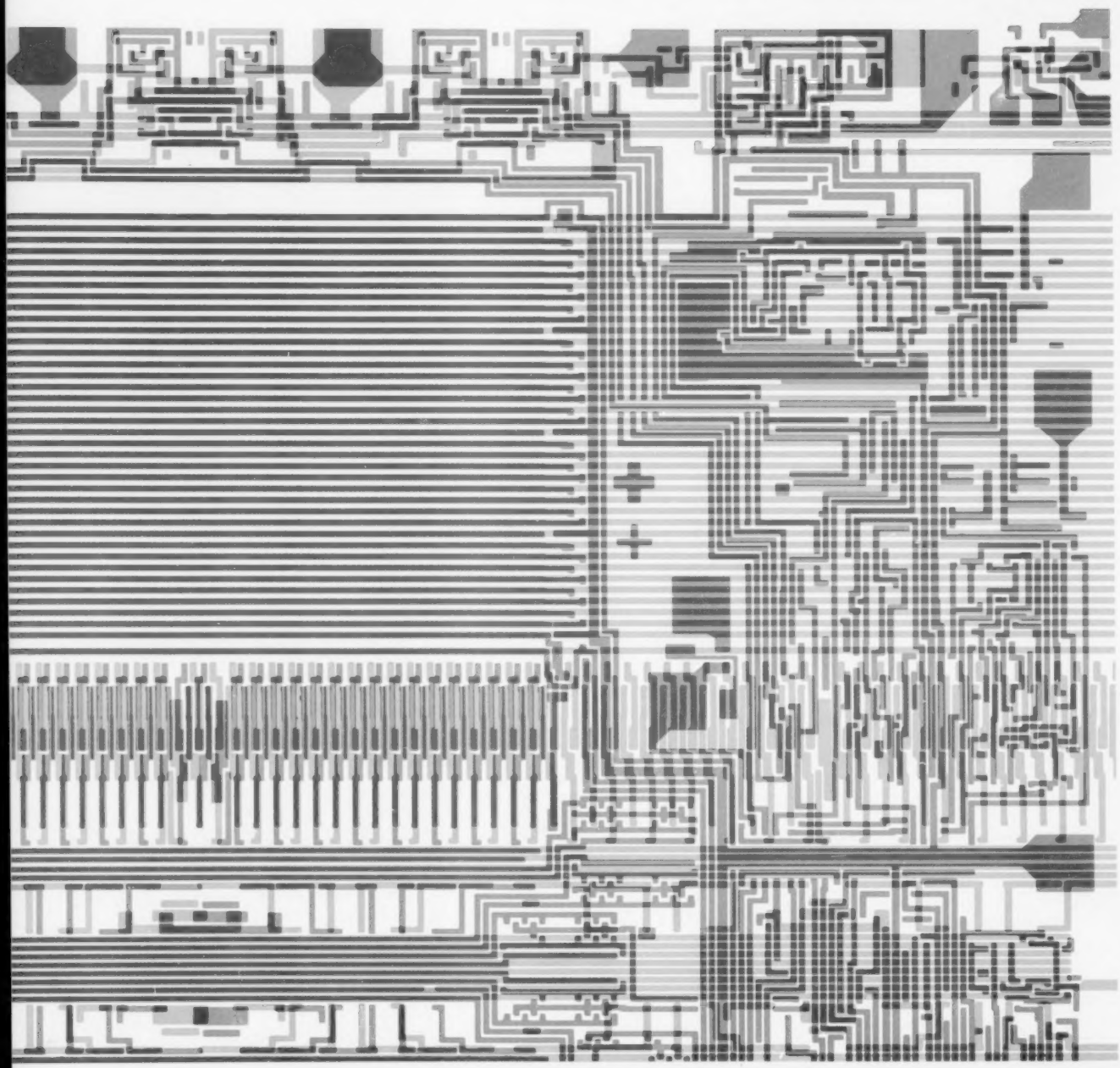
EDUCOM

Bulletin of the Interuniversity Communications Council (EDUCOM) Vol. 13 No. 1 / Spring 1978



The Departmental Computer • Merit Computer Network
Economics of Campus Computing

Reader Comment

Dear Editor:

The article by Ames and Carpino in your Winter 1977 issue seems to indicate that there may be a decline in the need for computing in various areas within the California State Universities and Colleges (CSUC). This purported decline is based upon a comparison of the 1972 and 1976 Instructional Workload Survey projections for 1980. I feel I must make the following comments, since I have been involved in this area since 1970 and California State College, Bakersfield, was one of the pilot campuses for the survey.

Having participated in both surveys, I cannot argue with the data or the analysis. However, I do feel that there are other factors that may have contributed to the anticipated decline in computer use in some areas. Both surveys were conducted to provide concrete data to support arguments for a major computer procurement. The 1972 survey was to have culminated in a 1974 installation and the 1976 survey in a 1978 installation, neither of which did or will take place. The installations are now projected for late 1979 or 1980 at the earliest.

As Ames and Carpino point out, some areas (hard sciences and business) have not reduced their anticipated usage but may have lowered their expectations slightly. Some areas (social sciences and technical disciplines) have held steady and others (humanities, fine arts, and languages) have declined. Only one area (architecture and communications) shows an increase.

If one examines these areas with respect to their traditional association with computing, it is obvious that the closer the areas have been associated with computing, the higher the expectation for the future.

One has only to consider human nature, I believe, to discover why the 1976 survey results are as reported. Since late 1971, the CSUC system has been promising its campuses that the antiquated, overburdened computing equipment would be replaced with more modern and more powerful systems. At several points along the chronological path, some improvement has been made, notably local campus upgrades, a new central timesharing system, and local campus timesharing. However, for the most part the sentiment at the campuses has been analogous to that of villagers in the fable of the shepherd boy who cried "wolf" too many times.

I have personally observed faculty members in the social sciences and humanities areas become "turned on" to computing and gear a class or two to be dependent upon computing, only to discover too often and too late that when the entire class began to use the systems, the computing power available was not sufficient to meet the needs in a reasonable time frame. Human nature being as it is would dictate, in my opinion, a turn-off, wait-and-see attitude on the part of faculty members in those areas where computing is an enhancement rather than an absolute requirement. In all too many cases, I believe, this is the reason why faculty members are not advocating the use of computing in 1980 as highly in 1976 as they did in 1972. If your computing needs had historically remained unsatisfied, and for five years somebody dangled a carrot in front of you that you somehow never could reach, would you expect your needs to magically be fulfilled in 1980?

John C. Biddle
Director of Institutional Studies and ADP
California State College, Bakersfield

EDUCOM BULLETIN

Vol. 13 No. 1 / Spring 1978

Chairman of the Council
James Poage
Princeton University

Board of Trustees Chairman
Joe B. Wyatt
Harvard University

Board of Trustees Vice Chairman
David Mintzer
Northwestern University

Institutional Trustees
Niels Anderson
University of Nevada
Laurence H. Baker
California State University
Weston Burner
Massachusetts Institute of Technology
John McCredie
Carnegie-Mellon University
Peter Meincke
University of Toronto
James G. Miller
University of Louisville
David Mintzer
Northwestern University
Charles Mosmann
University of California, Irvine
Louis Parker
University of North Carolina
Peter Roll
University of Minnesota
Robert Scott
Harvard University

Trustees-at-Large
Hugh C. Atkinson
University of Illinois Library
Henriette Avram
Library of Congress
Paul Bortz
U.S. Department of Commerce
Anne Branscomb
Kalba-Bowen Associates
Henry Chauncey
Former President, EDUCOM
Richard K. Greenfield
St. Louis Community College
William Massy
Stanford University
George A. Russell
University of Missouri—Kansas City
Frederic G. Withington
Arthur D. Little, Inc.
Joe B. Wyatt
Harvard University

Ex Officio Trustees
Ronald Brady
University of Illinois
Council Chairman Past
James F. Poage
Princeton University
Council Chairman
John McCredie
Carnegie-Mellon University
Council Chairman Elect
James C. Emery
President, EDUCOM

Trustee Emeritus
Ward Darley
University of Colorado Medical Center

Officers
James C. Emery
President
H. Eugene Kessler
Vice President, Finance and Administration
Carolyn P. Landis
Secretary

Contents

2 **The UCSD PASCAL Project**
by Kenneth L. Bowles

8 **The Merit Computer Network**
by Eric M. Aupperle and Donna L. Davis

19 **Employment Exchange**

20 **The Coming Challenge of Campus Computation**
by James C. Emery

24 **EDUCOM Seminars 1978**

Newsbriefs, inside back cover

EDUNET News, following page **14**

The UCSD PASCAL Project

Kenneth L. Bowles

Kenneth L. Bowles is a professor of electrical engineering and computer science at the University of California, San Diego (UCSD). He currently teaches the large introductory computer science courses at UCSD, and is director of the interdisciplinary Institute for Information Systems. Dr. Bowles received his Ph.D. degree from Cornell University. From 1967 until 1974 he was director of the UCSD computer center. During 1977 he conducted regional seminars for EDUCOM on the subject of the "departmental computer." The Terak microcomputer, on which the seminars focused, is offered under the EDUCOM Discount Program.

Summary

Small stand-alone microcomputers can serve as the basis for running a sophisticated general-purpose interactive software system capable of supporting CAI, word processing, data processing, and other interactive tasks in addition to development of the software itself. The project described in this article has implemented such a software system using the PASCAL programming language. The system is designed to be nearly machine independent, and currently runs on a number of microprocessors, including the popular LSI-11, 8080, and Z80. Except for a small interpreter program, which emulates a hypothetical computer idealized for PASCAL, all other programs in the system run identically on any host processor.

The project supports the teaching of a large introductory course on problem solving and programming using the PASCAL language. The use of PASCAL is growing very rapidly. Already widely used, it seems destined to become one of the major languages in the near future. The course materials consist of a self-contained package based on Keller's Personalized System of Instruction (PSI), including textbook, automated interactive quizzes, and bookkeeping software, in addition to the underlying PASCAL-based software system. Because PSI courses place very little emphasis on lectures, the author believes that this packaged course could be taught at many campuses with good results comparable to those achieved at his campus, yet with minimal intervention by the faculty members. The project plans to provide remote support, via dialed tele-mail using the microcomputers, for campuses that use this package. The software includes a subsystem for authoring of CAI materials based on the techniques developed at the University of California, Irvine.

Another important activity of the project has been a continuing search for high-quality microcomputer equipment, at minimum cost, for use in teaching and other applications. As a result of collaboration with the EDUCOM office, a microcomputer based on the LSI-11 microprocessor will be available through the EDUCOM Discount Program at about $5500 per unit. The graphics display capability of this machine makes it especially useful for teaching. Since it has communication capability, this machine can be used both as a general-purpose departmental computer and as an intelligent terminal.

Project Overview

The project described here began as an effort to provide minimal-cost computing facilities for introductory computer science classes, using stand-alone microcomputers. It was decided early to use the PASCAL programming language both for teaching and for development of virtually all of the necessary software. PASCAL was already widely used and respected for teaching modern concepts of systematic program development, or "structured programming." It is now coming into widespread use, with extensions, as a language for efficient development of large software systems. Another early decision was to use non-numerical programming examples, particularly those using graphic images, to avoid having to require students to have a strong mathematics background. In the search for economical and reliable equipment, it became apparent that the industry was developing newer and cheaper hardware at a pace that could easily outrun the development of software and interactive course materials. Accordingly, the necessary software has been designed to allow operation on a wide variety of microprocessors and miniprocessors, with only a small effort

needed to implement it on a new processor.

The project is one of the principal activities of the Institute for Information Systems (IIS) at the University of California, San Diego (UCSD). Like other organized research units, IIS is operated primarily to provide resources with which and activities within which students and faculty members can conduct research and development projects. Within the range of these projects, instruction and other public services may be supported, although most organized research units concentrate on basic research. One outcome of the UCSD PASCAL project has been the development of a general-purpose software system based on the PASCAL language for use in stand-alone microcomputers. The system has matured to the point where it has attracted the interest of many people outside the UCSD community.

One outcome of the UCSD PASCAL project has been the development of a general-purpose software system based on the PASCAL language.

Accordingly, IIS is distributing copies of this software at a $200 fee that pays for student part-time assistants who provide support to users and maintain the software. Under prevailing policies of the University of California, the fees charged may not be used to recover capital costs for software distributed to others. A number of interested industrial firms have provided assistance to further the development work of the project through unrestricted grants, and these currently are the principal source of operating funds for the project.

The research and development interests of the project focus on:

1. Methods of making large software systems for small computers more readily transportable to new processor architectures. Work is proceeding to make conversion from one processor to another as nearly automatic as possible.
2. The use of microcomputers as intelligent communications devices to assist people to work together even over distances of thousands of miles. This interest ranges from a desire to support users of the project's software package more effectively, to the investigation of complex software issues in the field of distributed computation.
3. Microcomputer-based mass education, using Keller's Personalized System of Instruction and CAI methods, as a means of offering high-quality college-level instruction at lower costs per enrolled student than costs associated with conventional methods.
4. Exploration of possibilities and software problems associated with new hardware devices or architectures adaptable to the purposes already described. Examples include video discs, low-cost X-Y input devices in communication applications, and strategies for interconnecting many semi-independent microcomputers.

There are openings for graduate students interested in software engineering or other computer science aspects of the project. An ancillary interest of the project involves promoting the standardization of the extensions to PASCAL that are commonly needed when the language is used for interactive programs or other large system programs.

Why PASCAL?

PASCAL is a general-purpose programming language introduced by Niklaus Wirth as a vehicle for teaching concepts of systematic program design and as a basis for writing software such as compiler programs.[1] PASCAL has a block structure somewhat similar to ALGOL, but it also offers extensive facilities for data structuring. The language first drew worldwide attention in academic computer science departments. More recently, it has been used by a rapidly increasing community as the base language for software development. An international PASCAL users' group, coordinated by Andy Mickel at the University of Minnesota, has a diverse membership of about 1500 and publishes a voluminous quarterly newsletter. The users' group invites others to join, at an annual subscription of $4.00. In a major

PASCAL embodies directly the control constructs that programmers are urged to simulate in using FORTRAN, BASIC, or COBOL for structured program development.

current project of the U.S. Department of Defense, PASCAL is being used as the base language for a new system development language expected to be the standard for future work of the department.[2] In the mass trade press of personal computing, a recent editorial conjectured that PASCAL might eventually replace BASIC as the most popular language in that field.[3]

Why is PASCAL attracting all this interest? The reasons are primarily economic, and associated with the effort to use the method often called "structured programming" as a way to reduce the time needed to develop large programs, and to improve the possibility that once developed they will work correctly. PASCAL embodies directly the control constructs that programmers are urged to simulate in using FORTRAN, BASIC, or COBOL for structured program development. PASCAL data structures, such as records and sets, allow relatively clean and direct programming of actions that often require messy indirect strategies in the other languages. When supplemented with relatively minor extensions, PASCAL can be used for development of efficient system programs, such as compilers, editors, and operating systems, which typically have been written in assembly language in the past. While there have been other languages developed and used for similar goals during recent years, PASCAL seems

Microcomputers are used to handle many routine aspects of the duties normally assigned to the proctors . . . allowing the overall labor costs to be comparable to or less than costs of conventional instruction.

to have been promoted with the right combination of circumstances to attract a wider and faster-growing community of enthusiasts. It has been implemented on over 60 computer models ranging in size from the Cray-1 supercomputer to the 8080 microprocessor, and it is supported by both introductory and advanced textbooks.

UCSD's Introductory PASCAL Course and Textbook

The course associated with the UCSD project comes close to matching the specifications for course CS1 in the recently published curriculum recommendations of the Special Interest Group on Computer Science Education (SIGCSE) of the Association for Computing Machinery (ACM). The course is the principal introduction to problem solving with computers at UCSD, with approximately 500 students enrolling each quarter. In order to reach the many students who come to the campus with inadequate preparation in high school mathematics, a non-numerical approach is emphasized. However, the problem solving and programming approaches used are the same as taught in traditional introductory computer programming courses, which typically use many example problems drawn from numerical mathematics.

The course structure is very similar to the Personalized System of Instruction (PSI) originally described by Fred Keller,[4] and analyzed extensively in subsequent publications.[5] In several recent papers, PSI has been shown to achieve consistently superior results when compared with virtually all other teaching techniques widely used at the college level.[6,7,8] PSI is the cornerstone of a family of methods that provides individualized instruction. It has been described as an "instructional revolution" by a leading analyst of educational systems.[9] The unusual effectiveness attributed to PSI relies heavily on individual attention to students provided by teaching aides known as proctors. This reliance means that, without computers, the typical PSI course requires somewhat more labor than conventional college courses. In the UCSD project, microcomputers are used to handle many routine aspects of the duties normally assigned to the proctors. This allows an increased fraction of the proctors' time to be devoted to individual instruction and allows the overall labor costs to be comparable to or less than costs of conventional instruction.

Students in the course described here are given a brief orientation to the class organization and hands-on use of the microcomputers during the first week of the academic quarter. Thereafter, they proceed through the course materials in the textbook and study guide at their individual paces. The organized class activity is concentrated in a teaching laboratory, which contains the microcomputers, and is open at least 80 hours per week. At all hours when the laboratory is open, it is staffed by two or more proctors who function as learning assistants. Duties of the proctors include grading homework and quizzes and consulting with students. The proctors are usually experienced students at the graduate or undergraduate level. Quite often, the best proctors are undergraduates who scored well in the same course in a previous academic term.

The course is subdivided into study units, each of which corresponds to the work in one chapter of the textbook written explicitly to support this course.[10] A student must be graded as having passed both homework and quiz for a unit before moving on to the next unit. Grading is on a go/no-go basis for each unit. If a no-go grade is received, the student may try again on similar material after allowing time for additional study. Grading of homework is accomplished through an interview conducted by a proctor, in which the proctor attempts to ascertain whether the student understands the content of the problem being solved (in addition to turning in correct results). The interview provides an opportunity for the student to ask questions about aspects of the material not fully understood, and for the proctor to prod students into applying their knowledge to generalized situations.

In most PSI courses, the quizzes are graded immediately after being turned in by a student, using an interview process similar to that just described. For practical reasons, it is not generally possible to administer a comprehensive quiz at the end of each unit, at least in the subject of this course. One must be satisfied with random selection from a suite of quizzes covering the subject matter of a unit. The learning goals for each unit, and hence the subjects covered in the quizzes, are announced clearly in the study guide or textbook. Serious students come to take quizzes prepared to answer questions on any of the announced topics. Unfortunately, many of the students learn that it is possible to beat the system by selecting proctors who grade less conscientiously than the average, or by intentionally failing to pass quizzes on topics that prove harder than others to learn. On studying student behavior patterns, the author has come to realize that the same kinds of behavior, and the same failings of teaching

assistants, are present in conventional courses as well as in those taught using PSI. The PSI format, at least with large classes, makes it much easier to observe these behaviors and leads one to seek practical methods of controlling them.

It is the immediate feedback aspect of the PSI grading interviews that is generally credited for the superior performance of students with PSI. In a conventional course, the student may not learn that his or her understanding of an aspect of the subject is incorrect until many hours or days of studying have been wasted. Students in PSI courses generally find that conventional lectures are redundant, even if well prepared and presented, assuming that the subject material is present in the textbook. (If lecture material is not presented in the textbook, the instructor generally experiences serious problems in informing all of the proctors about the supplementary materials that are presented in lectures.) As a result, the lecture attendance in a well-prepared PSI course drops dramatically after the first few days of a term. As others have found in similar courses, lecture attendance in the course described here is negligible after about four weeks; further lectures are generally cancelled. Keller originally proposed that lectures should be used as a motivational device, and that only students who have progressed beyond a specified number of study units should be admitted to any given lecture. In a recent paper, Thomas Taveggia states that there is evidence that lectures contribute little or nothing to the educational value of a PSI course.

Using Automation to Supplement Proctors

After using PSI to teach the same course for several quarters, one discovers that much of the proctors' time is consumed by routine activities, or seemingly endless repetition of intellectual activities that become routine. Whereas some practitioners of PSI prefer to assign each student to a specific proctor, students in the course reported here are allowed to come to the laboratory whenever they wish, effectively allowing them to select the proctors they prefer. This method allows a natural matching of personalities, but it requires the proctors to spend a great deal of time maintaining records.

Experienced proctors also notice that they are repeatedly requested to answer the same few questions, and to correct the same few student errors. The better proctors recognize this pattern as evidence of shortcomings in the course presentation materials, and suggest improvements. However, many of the problems that students experience are inherent in the subject, and the only remedy is drill and practice. The less conscientious proctors eventually become bored by the repetition, and they allow students to pass the unit quizzes and homework without requiring sufficient evidence of understanding. Moreover, proctors are so busy that they are forced to take shortcuts to keep the class moving along.

In this project, automated quizzes have been found to be an exceedingly effective supplement for the proctors. The quizzes employ a number of drill-and-practice strategies adapted to the subject of this course from strategies developed at the University of California, Irvine.[11] One of the most effective is the concealed multiple choice strategy, in which the computer presents only one of several alternative answers at a time in a randomly selected sequence. The student is required to correctly identify whether each selection is correct or incorrect until the correct choice appears. In addition, many of the quizzes require quantitative answers. In both cases, the quiz-generating programs use random selection in such a way as to provide a very large variation in the details contained in a quiz each time it is presented. Whenever a question is answered incorrectly, the computer displays the correct answer and a brief explanation. In most cases, this immediate reinforcement is sufficient to clear up a misconception, and the student does not need to request additional help from a proctor.

In addition to providing a method of measuring student progress, the automated quizzes encourage the students to think through all of the important topics of a study unit. Each student is issued a self-test copy of a quiz program to be studied, in general, before taking the quiz for formal grading. Though the self-test and formal versions are basically the same programs, the probability is extremely small that the student will encounter the same questions in both versions. The self-test version allows a small group of students, working as a study team, to reinforce each other on minor points of misconception without having to call in a proctor for assistance. Proctors are available to explain fine points to students during their review of the self-test quizzes, and also to clear up minor points of misunderstanding when the formal quizzes are taken.

Automated quizzes have made it possible to accomplish several objectives that were beyond the resources of the project using completely manual methods.

The automated quizzes have made it possible to accomplish several objectives that were beyond the resources of the project using completely manual methods. First, it has become practical to require each student to take a quiz covering all of the topics in a study unit. This prevents students from using the quiz selection tactic. Second, it has become practical to ensure that all proctors have proficiency in all of the subject material of the course. Even the most experienced graduate student proctors sometimes identify as "bugs" in the quiz programs detailed properties of the course materials that are in fact correct. Third, the time spent by the proctors in maintaining records has been greatly reduced through automated recording of the students' performance on formal quizzes. In combination, these factors have doubled or tripled the amount of proctor time available for direct consultation with students on the more subtle aspects of the course.

The CAI package has been designed for use with graphic display devices having selective update capabilities.

The Software Package

The software package used by the project, and made available to others, is based on a complete single-user operating system written in PASCAL. The principal modules of the system, which operate on many makes and models of minicomputers and microcomputers, include the following:

- PASCAL compiler
- file manager (capabilities similar to Digital Equipment Corporation's PIP program)
- screen-oriented editor (cursor positioning, updates seen on screen immediately)
- line-oriented editor (similar to DEC's editor in the RT-11 operating system)
- debugger (single-line execution, reference to variable contents)
- setup program (adapting system to most ASCII terminals)
- BASIC language compiler (ANSI standard plus strings)
- library of utility programs

The CAI package includes a family of built-in functions designed to ease the task of the author of the course materials. The approach used is similar to, and patterned after, the CAI system developed by Alfred Bork and his colleagues at the University of California, Irvine.[12] Changes have been made to adapt the Irvine approach to programming in PASCAL and for operation on small microcomputers instead of the large time-shared system used at Irvine. The CAI package has been designed for use with graphic display devices having selective update capabilities. Currently, experience with this package has been limited to the Terak 8510A microcomputer. Adaptations will be made to other devices when the opportunities arise. Subsets of the CAI modules written to use only alphanumeric displays, or only graphics without selective update, will probably run with minimal adaptation on other popular display devices.

In the course of implementing this software system and the associated materials for teaching introductory programming, it has been necessary to extend the PASCAL language as originally defined by Wirth.[13] The extensions needed for teaching allow convenient manipulation of strings of characters as well as the plotting of line drawings, and are described in the textbook for the course. Additional extensions have been made to allow the operating system, compiler, and other software modules to operate efficiently, and to control peripheral devices. The author has found that most industrial organizations using the PASCAL language for system programming have also found it necessary to extend PASCAL to do their work. In general, the extensions made by these organizations serve the same purposes as the UCSD extensions. Currently, there is no organized effort to standardize these extensions and thus prevent a proliferation of different ways to solve similar problems by extension of the same base language. There is a danger that PASCAL will thus succumb to the same problems that have made it difficult to move programs written in BASIC from one system to another. Accordingly, the UCSD project is attempting to coordinate the extensions being made by a group of the industrial users of PASCAL in an effort to produce a common set of standard extensions.

The entire UCSD PASCAL system runs on a "pseudomachine" which emulates a hypothetical hardware processor designed to execute compiled PASCAL programs. In the jargon of software engineering, the pseudomachine is known as an interpreter – a small program in the native instruction set of the host processor on which it runs. Currently, the project is producing interpreters by hand coding in assembly language, a process that takes an experienced programmer four to six months of full-time work (with run-time support modules included). Work is proceeding to reduce this time by automating as much of the process as possible.

The use of the interpreter allows the entire software system to be run with virtually no change on a wide variety of microcomputers and minicomputers. To avoid the kind of practical problems that have discouraged use of this approach in the past, the project is concentrating on the large family of processors oriented to 8-bit bytes and/or 16-bit words. Currently, the project is supporting the software to run on computers built around the DEC PDP-11 series processors, particularly the LSI-11, and those using the 8080 and Z80 microprocessors. Work is proceeding under various collaborative arrangements with other groups to implement the system on the Univac Data Machines V75, the General Automation 440, and the Nanodata QM-1. The project is seeking sponsors to allow implementation on other popular microprocessors or minicomputers.

The interpretive approach has advantages and disadvantages. In addition to promoting machine independence, the pseudomachine allows interpretation of compiled object code that has been defined to make economical use of the computer's main memory. Thus, the compiler consumes 20K bytes instead of the 60K bytes or more that it would consume if implemented in the native code of any of the popular computers in use today. A disadvantage is that the pseudomachine runs at about one fifth the speed at which the optimum native code would run on its host machine. For frequently used programs like the PASCAL compiler, this problem is partly overcome through the use of a small number of built-in routines that run in native code. The result is that large PASCAL programs are compiled on the LSI-11 and Z80 processors at roughly 650 lines per minute. This is sufficient to make unnecessary the tactic of cross-compiling software on a large machine, with the object code intended to run on a microcomputer. A secondary benefit of the effort to automate implementation on new processors is that

users will be able to specify that selected routines in a program be compiled directly into native code on the host machine.

Readers interested in using the UCSD PASCAL software package are welcome to contact the author at the Institute for Information Systems, UCSD, La Jolla, California 92093. Because of the volume of interest in the project, a telephone call to 714-452-4526 will generally be received by one of the student members of the project. The minimum practical configuration needed to run the software package with the compiler would have at least 48K bytes of main memory. The Terak 8510A and PDP-11 computers used for most purposes by the project have 56K bytes, and this has proven sufficient (so far) for compiling even the largest software modules. The system is designed with the assumption that the secondary storage device will be a floppy-disk drive. For many purposes – disk-to-disk copying of files, for example – two floppy-disk drives are needed. Copies of the system have also been distributed for use with DEC RK05 hard-disk drives, or the equivalent. Substantial problems have been encountered in attempting to distribute copies of the software on media other than standard IBM 3740 compatible floppy disks, or on RK05 compatible hard disks. Attempts are being made to be more flexible in this area. However, doing so would entail a large drain on project resources, so no promises can be made.

User Support

Within its limited resources, the project is attempting to support users of the UCSD PASCAL software package in as professional a manner as possible. The $200 fee paid by those who order the system is treated as a subscription to the project's support services for 12 months after the system is shipped. Since the system is continually being improved and enlarged, major releases of the package will be made approximately three times per year. These will be sent automatically to those who have subscribed to the service.

Between major releases the project is attempting to answer requests for clarification, and for occasional assistance on programming problems. Eventually, if the packaged set of course materials (textbook, automated quizzes, PSI-oriented bookkeeping for grades, suggested study guide, manual for proctors) is adopted by other campuses, it is planned to provide call-in expert assistance for proctors at those campuses. For both purposes, use of the voice telephone would be of limited value. A more effective approach would entail using the microcomputers part time for transfer of message files via the public telephone network. The author prefers to call this technique "dialed tele-mail" instead of "electronic mail," which can be confused with a different concept being considered for the U.S. Postal Service.

A computer will be used 24 hours a day to provide dial-in tele-mail response to users of the project's software system.

As this article is being written, the project is preparing to install a microcomputer to be used 24 hours a day to provide dial-in tele-mail response to users of the project's software system. This service will be reachable initially only by using a special communication program distributed to the user of the software system for this purpose. It will not be possible to reach this service from simple computer terminals. It is intended that the turnaround time will be only a few minutes for responses to requests made during the regular business day (Pacific time). At other times, messages may be left for the project on the project's tele-mail machine, or received from the project by calling that machine. It is expected that the tele-mail service will allow more effective interchanges, involving abstract subject material, than is possible with the voice telephone. □

References

1. Niklaus Wirth. "The Programming Language PASCAL." *Acta Informatica*, vol. 1: 35–63.

2. William A. Whitaker. "The U.S. Department of Defense Common High Order Language Effort." Unpublished memorandum circulated January, 1978, by the Advanced Research Projects Agency, Arlington, Virginia.

3. Carl T. Helmers. "Is PASCAL the Next BASIC?" *Byte Magazine*, vol. 2, no. 12: 6, 8, 184–185.

4. Fred S. Keller. "Goodbye Teacher . . . ." *J. Appl. Behav. Anal.*, vol. 1: 78–89.

5. J. Gilmour Sherman, ed. "Personalized System of Instruction, 41 Germinal Papers." Menlo Park: W. A. Benjamin, 1974.

6. Daniel E. Hursh. "Personalized Systems of Instruction: What Do the Data Indicate?" *J. Personalized Instruction*, vol. 1: 91–105.

7. Thomas C. Taveggia. "Personalized Instruction: A Summary of Comparative Research, 1967–1974." *Am. J. Physics*, vol. 44: 1028–1033.

8. Thomas C. Taveggia. "Goodbye Teacher, Goodbye Classroom, Hello Learning: A Radical Appraisal of Teaching-Learning Linkages at the College Level." *J. Personalized Instruction*, vol. 2: 119–122.

9. K. Patricia Cross. "Responding to New Learning Needs." Proceedings of the Joint Conference of the University of California and the California State University and Colleges, December 3–5, 1976: 25–45. Berkeley, 1977.

10. Kenneth L. Bowles. *Problem Solving Using PASCAL*. New York: Springer Verlag, 1977.

11. Stephen D. Franklin. "Interactive Computer Based Testing in Pre-Calculus Mathematics." Research report of the Department of Mathematics, University of California, Irvine, 1976.

12. Alfred Bork and Joseph Marasco. "Modes of Computer Usage in Science." *THE Journal (Technological Horizons in Education)*, vol. 4, no. 1: 13–19.

13. Kathleen Jensen and Niklaus Wirth. *PASCAL User Manual and Report*. New York: Springer Verlag, 1975.

The Merit Computer Network

Eric M. Aupperle and Donna L. Davis

Eric M. Aupperle is director of the Merit Computer Network, an interuniversity computer network developed by Michigan State University, the University of Michigan, and Wayne State University. He is also a registered professional engineer in the state of Michigan. Prior to becoming the director of Merit, he was a research engineer at Cooley Electronics Laboratory at the University of Michigan and lectured in the Department of Electrical and Computer Engineering. He has served as a research scientist with the Institute of Science and Technology at the University of Michigan since 1969. Mr. Aupperle holds B.S.E. degrees in electrical engineering and mathematics, an M.S.E. degree in nuclear engineering, and the Instm.E. professional degree from the University of Michigan.

Donna L. Davis is an EDUCOM staff member assigned to the Network Simulation Project, a large research project funded by the National Science Foundation. The project is investigating the desirability and possible impact of a national computer network for education and research. Donna's responsibilities include both administrative and research activities. She holds a B.A. from the University of Rhode Island.

Acknowledgment: Merit's Christine Wendt has made a major contribution to this article. Her help is gratefully acknowledged.

Introduction

The technology of a computer network is a primary factor in determining its success. However, technical feasibility is a given in today's world, and the critical factor now is the effectiveness with which existing capabilities are implemented and refined. Another important factor in network success is the way in which operational and administrative considerations are integrated into the implementation. The solution of some of the fundamental technological problems has enabled network designers to concentrate on these other issues. Just as a network cannot exist without technology, it will not work without attention to these areas.

The Merit Computer Network is well worth examining in terms of both the technology and the administration and operation of the network. It is fully operational and has a significant and rapidly increasing usage, with three major institutions now actively sharing computing resources over this system. It is the way in which Merit has dealt with and anticipated technological and management problems that has made it such a success.

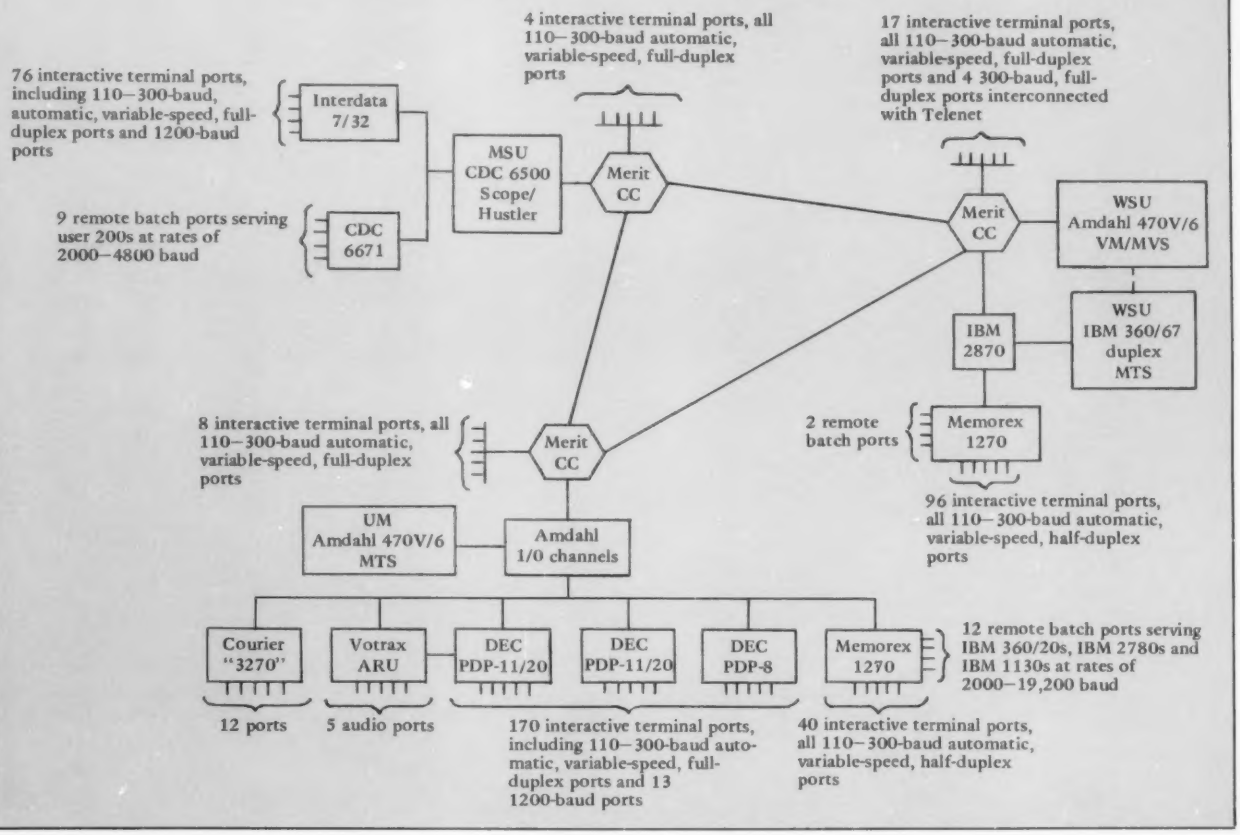
Background

Michigan State University, the University of Michigan, and Wayne State University are Michigan's three largest universities. Together they enroll 125,000 students and employ about 8700 faculty members. Each of these institutions maintains a large computing center to serve the computational needs of its students, faculty members, and research staff. Recognizing that they could benefit from sharing their computing resources, the three universities joined together in 1966 to form the Michigan Interuniversity Committee on Information Systems (MICIS).

In broad terms, MICIS's task was to explore the use of computers in

Figure 1

System Configuration of the Merit Computer Network


4 interactive terminal ports, all 110–300-baud automatic, variable-speed, full-duplex ports
17 interactive terminal ports, all 110–300-baud automatic, variable-speed, full-duplex ports and 4 300-baud, full-duplex ports interconnected with Telenet
76 interactive terminal ports, including 110–300-baud, automatic, variable-speed, full-duplex ports and 1200-baud ports
Interdata 7/32
MSU CDC 6500 Scope/ Hustler
Merit CC
Merit CC
WSU Amdahl 470V/6 VM/MVS
9 remote batch ports serving user 200s at rates of 2000–4800 baud
CDC 6671
IBM 2870
WSU IBM 360/67 duplex MTS
8 interactive terminal ports, all 110–300-baud automatic, variable-speed, full-duplex ports
Merit CC
2 remote batch ports
Memorex 1270
96 interactive terminal ports, all 110–300-baud automatic, variable-speed, half-duplex ports
UM Amdahl 470V/6 MTS
Amdahl 1/0 channels
Courier "3270"
Votrax ARU
DEC PDP-11/20
DEC PDP-11/20
DEC PDP-8
Memorex 1270
12 remote batch ports serving IBM 360/20s, IBM 2780s and IBM 1130s at rates of 2000–19,200 baud
12 ports
5 audio ports
170 interactive terminal ports, including 110–300-baud automatic, variable-speed, full-duplex ports and 13 1200-baud ports
40 interactive terminal ports, all 110–300-baud automatic, variable-speed, half-duplex ports

information processing and exchange. As MICIS focused on ways to maximize the advantages of integrating the different system characteristics and varying system demands of the three computing centers, its objectives were refined into a proposal for a prototype statewide computing network. With support from the Michigan legislature and the National Science Foundation as well as contributions of computer time and other services from the three universities, the Merit Computer Network was formed.

Merit became fully operational in October 1972. Today it is a powerful telecommunication system that not only serves the needs of users at the three host institutions but also provides for expansion to other colleges and universities and for connection to other computer networks.

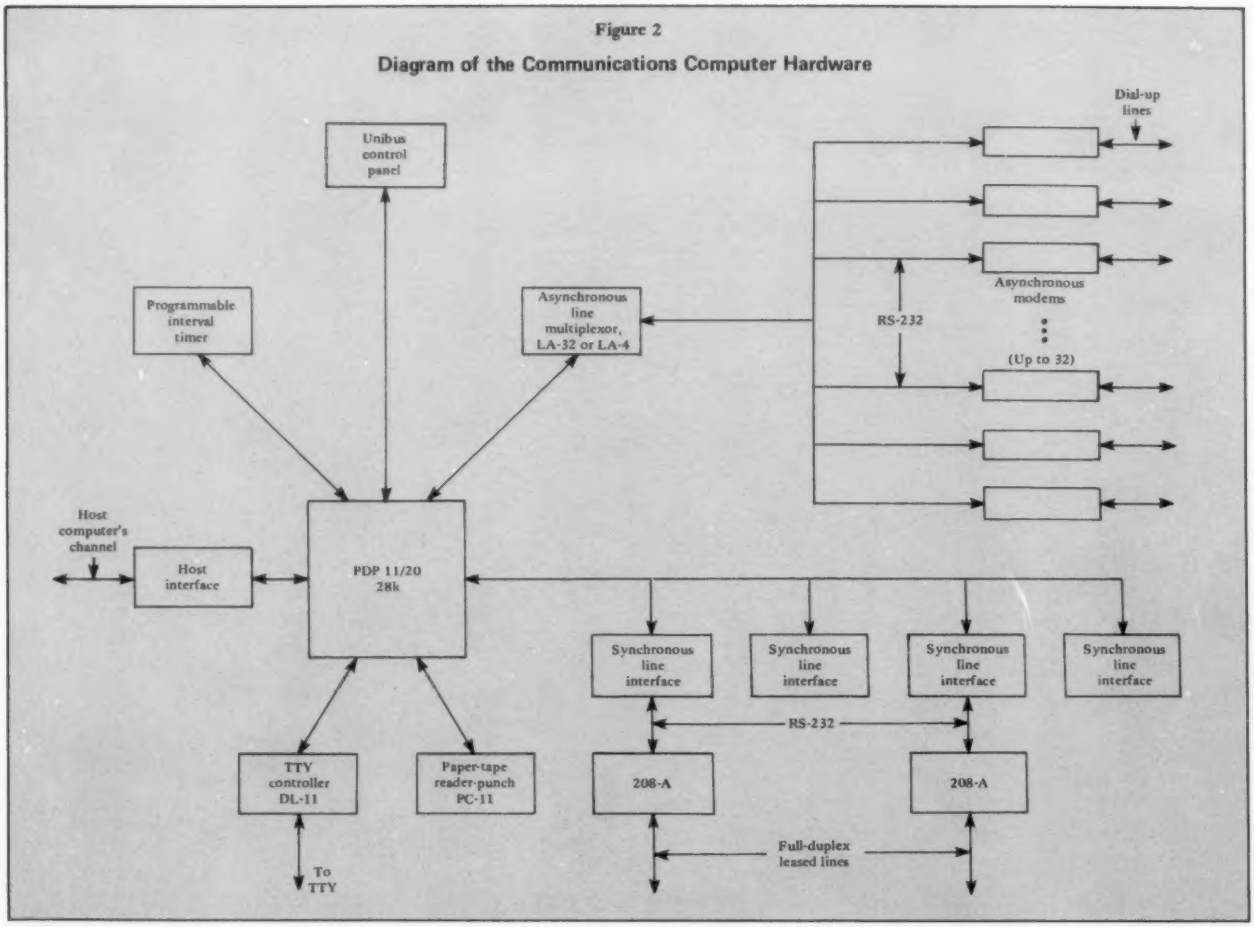
Network Configuration and Services

Host systems. The Michigan State University (MSU) host computer is a Control Data Corporation (CDC) 6500 with 100,000 words of central memory and 500,000 words of extended core storage. It runs under a locally modified version of CDC's SCOPE operating system and supports nine remote batch stations and 76 terminal ports in addition to its network ports. (MSU also has a CDC 6400 with 65,000 words of central memory, which does not have a direct connection to the network.) The university's CDC hardware features a 60-bit word size, in contrast to the 32-bit word size of the IBM and IBM-compatible hardware at the University of Michigan (UM) and Wayne State University (WSU). Thus, one of MSU's principal contributions to the network is to supply extended-precision numerical and scientific computing. MSU also offers the CDC versions of such languages as FORTRAN and BASIC as well as CDC versions of SPSS and PASCAL, all of which feature extensions to the corresponding implementations of these languages at the other hosts. A locally written APL also offers a fuller implementation of that language than is available elsewhere on the network.

The University of Michigan has an Amdahl 470V/6 with six million bytes of real memory, running under a locally written virtual-memory operating system, the Michigan Terminal System (MTS). The UM host system supports 12 remote batch stations and 227 interactive terminal ports. The Amdahl 470V/6, approximately five times as fast as the earlier duplex IBM 360/67, provides a powerful network host that, like the WSU system, is able to manipulate very large data bases. Packages such as MIDAS, an

Figure 2

Diagram of the Communications Computer Hardware



interactive statistical system, have been written at UM to take advantage of this combination and account for a good portion of network usage at UM.

The host computer at Wayne State University (WSU), which also runs MTS, is a duplex IBM 360/67 with four million bytes of solid-state memory. The system supports 96 interactive terminal ports and two remote batch stations. The WSU computing center emphasizes the production of high-quality printed copy for tables, graphs, and even the full texts of technical reports. WSU's flat-rate charging method, based only on elapsed connect time, provides extremely economical computing during the evening and night.

A particularly important resource at WSU is IBM's MVS, which runs on an Amdahl 470V/6 and serves the university's administrative data processing needs. While MVS is not accessible interactively through Merit, the MVS and MTS systems are interfaced through a tape-transfer link. This permits the submission of network batch jobs to MVS, making available a number of program products written for IBM's Operating System (OS) or MVS that are not available at either of the other hosts.

Network design. The three host systems are sufficiently different as to make desirable the directing of particular types of work from one to the other. Yet without the technical ability to interconnect the machines economically and to allow for growth and modifications, the potential benefits of resource sharing could not be realized.

It is important to note that one of Merit's initial design goals was to allow the greatest possible user flexibility. Another was to facilitate refinement and enhancement of the system without disturbing existing operations or requiring extensive modification. A third design goal was to make the network as transparent as possible to the user – that is, to make the network features seem to be extensions of the three operating systems. Thus, many network enhancements are not observed by users and do not affect host-user relationships.

The technological design of the Merit Computer Network goes beyond the directly connected host-to-host network by employing communications-switching computers, which act both as interfaces between the host computers and the network and as packet-switching nodes. A communications computer (CC) is located at each host site. The three CCs are interconnected by means of modems through leased telephone lines as shown in Figure 1. The interfaces that the CCs present to the host system are uniquely

adapted to the requirements of each particular host; the interfaces that the CCs present to the network (and thus to each other) are identical.

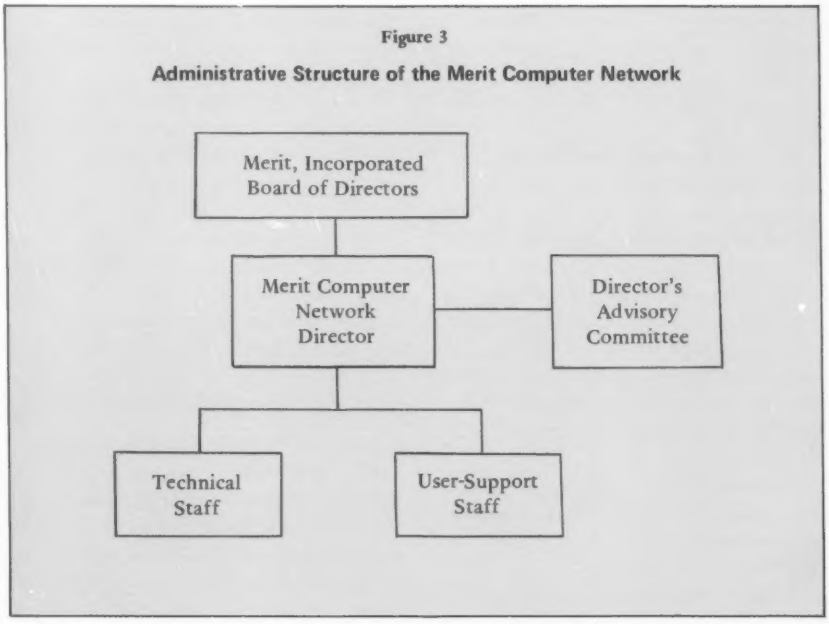
The CCs are Digital Equipment Corporation PDP-11/20s with 28K of 16-bit memory. Their primary functions are to multiplex virtual connections over physical communications links (communicating with other nodes using a binary synchronous communications protocol), to receive messages from their respective host computers for transmission on the network, to receive messages from other nodes for delivery to their hosts or for forwarding to another host, and support local dial-up terminals.

The PDP-11 of each CC is augmented with several interfaces as shown in Figure 2. The major interfaces are the host and the asynchronous and synchronous communications interfaces. The synchronous communications interfaces are designed to transfer entire messages over the telephone network directly to and from each PDP-11's core memory without program intervention, once the transfer is initiated by software action. Currently, only two of the four available units are used at each node. The active units are connected to AT&T Model 208A data sets. The data transmission is full-duplex at a rate of 4800 baud. These interfaces are designed to operate at rates in excess of 50,000 baud, however, when equipped with higher data rate modems. The asynchronous interface provides for up to 32 local dial-up ports. Each port may operate independently at any one of four transmission rates depending on the terminal currently accessing it.

All three of the host interfaces are special hardware devices that allow for the parallel transmission of data records to and from the memory of the CCs, performing whatever memory alignment operations are required for differing word-length capacities. The multiple-address host interfaces simplify the logical structure of multiplexing user activity over the network and thereby reduce the amount of network support software required in the host computers.

Figure 3

Administrative Structure of the Merit Computer Network



Types of User Service

Host-to-host interactive. When Merit began operation in 1972, host-to-host interactive service was the only kind of service offered. To use this type of service, a network user establishes a connection to a selected remote host through his or her local host. Once this is done, the user may interact with either the remote or the local system and may switch back and forth between them without losing the connection. Over such a connection, users can copy files between hosts, run a program at one host with either input or output or both transmitted in real time to or from the other host, and so forth. The network enables users to work on a remote computer while still using the local terminal operating conventions and keyboard editing modes to which they are accustomed.

Host-to-host interactive capability was developed first because it offered more flexibility and power than other types of service provided by networks.

Network batch. With network batch service, a user can submit a job at any host for subsequent execution, printing, and/or punching at any designated host or combination of hosts. The job typically enters the local host's batch queue and waits there until the batch service opens a network connection to transmit the user's job to the host specified. After transmission, the connection closes and the job waits on the remote host's execution batch queue. After execution, the job output goes through this transmission cycle in reverse, unless the user has specified that the output not be routed back to the site of job submission, in which case the output will print or punch at the site of execution (or possibly be routed to yet a third host). Similarly, output can be routed to a remote host for printing or punching without an execution phase

being involved. For example, a user can very easily use the network batch service to access a large text file at Wayne State for output on a line printer at Michigan State.

Network batch is a particularly efficient type of service, as it allows transmission to occur at the convenience of the network and the hosts involved without requiring the user to be logged in to any system at the time. Should any component of the transmission link fail during the transmission, the network automatically tries to retransmit the job from the beginning and continues to try until the job is successfully transmitted.

Interprocess communication. This service allows programs to be run concurrently on one or more host computers. The programs may be employed simultaneously or sequentially, and typically transfer data and results among themselves, from one host to another.

Direct network access. From the beginning, care was taken to allow for the provision of direct access to the network — that is, to enable users to dial directly into the network through a local CC. The network's direct-access facility, Hermes, was installed at the three host sites in 1975. Hermes provides an interface directly into the network so that access to a remote host is independent of the availability of the local host. Besides providing direct access to Merit, Hermes offers a number of features designed for user control over terminal behavior and input/output functions.

External access. A recent significant expansion in network services is the provision of external access. Late in 1976, the Merit Computer Network linked with Telenet, thereby allowing interactive use of the three Merit host computers from any city in North America (as well as from cities in many foreign countries) that is served by one of the Telenet dial-in access numbers. This internetwork link is currently implemented in the form of four 300-baud telephone circuits.

Organization and Operation

Administrative structure. Although the Merit Computer Network was founded by the original three member institutions of the Michigan Interuniversity Committee on Information Systems (MICIS), there is no formal relationship between Merit and MICIS, which expanded in 1973 to include representatives from all of Michigan's 13 state-supported colleges and universities.

A simplified view of the organization of the Merit Computer Network is presented in Figure 3. Merit, Incorporated, is a nonprofit corporation established by the original MICIS members in the fall of 1966. Its responsibilities include seeking funds for the development and operation of the Merit Computer Network and overseeing its administration. Merit, Incorporated, currently has three members, one from each of the participating institutions, who constitute Merit's board of directors. The director of the Merit Computer Network is appointed by the board of directors.

The Merit Computer Network staff develops and operates the network. All staff members, including the director, are employed by one of the three universities. Network personnel are organized as a central staff in Ann Arbor assisted by local staff at each participating institution. Merit's director is a member of MICIS.

The director receives support from three part-time associate directors, one at each campus. The chief responsibility of the associate directors is to serve as the network's principal user-level spokesmen at their respective institutions. Many policy questions and other network-related issues are handled by the director's Advisory Committee. This group consists of the Merit director, the associate directors, and the three computing center directors.

In addition to long-range planning, Merit's board of directors is responsible for ultimate policy decisions. Recommendations may be provided by individual users, they may stem from joint discussions by the aggregate user and technical staffs, or they may be initiated by the director's advisory committee. As a practical matter, all but the highest policy decisions are arrived at by the advisory committee — and there, primarily by agreements between the computing center directors and the Merit director. The computing center directors and the Merit director routinely meet with Merit's board of directors in order to participate in the decision-making process.

Merit's director is responsible for the execution of all technical and contractual responsibilities in three major areas: education and promotion, research and technical development, and financial administration.

In the educational and promotional functions, the director is assisted by the three associate directors. The special responsibility of each associate director is to promote the development of the network within his own community of users. Essentially, he has a dual role: to support the director and the network so that the implementation of the network at his own site proceeds as effectively as

Figure 4

Successful Network Connections

possible, and to ensure that his own university's interests are equitably served with respect to the demands made on its resources by the network.

Typically, the associate directors have had little time to devote to day-to-day network matters. The major burden of local support therefore falls on the user staff at the respective computing centers. Questions about the network which cannot be answered locally are referred to the network's user staff. Documentation about the network is slowly being incorporated into local computing center publications. Separate, network-wide manuals and memoranda are prepared by the network staff. Network seminars at the host sites are jointly arranged by the network and local staffs.

Four groups are concerned with the technical research, development, and operations: the network's technical staff and members of the systems programming staff at each of the three participating institutions. Merit's technical staff includes three full-time staff members who divide their efforts among research and development, operation, and maintenance.

Primary responsibility for financial administration rests with the director, who is supported by Wayne State University acting as fiscal agent for the network. WSU fulfills such functions as the receipt of funds from the three universities and the distribution of these funds to Merit's central staff. Currently, all of Merit's revenue comes from the three participating institutions. They share equally an annual budget of approximately $150,000.

User accounts. The actual resource-exchange mechanism is based on viewing the user as a customer who buys computing resources from a computing center – a supplier. When the supplier is affiliated with a network (as is the case with the three host universities), the range of its deliverable resources is extended beyond those of the immediate computing center to include the resources of other participating hosts. But the customer/supplier relationship continues to exist as though the supplier were the customer's own computing center. All network services appear to the customer to be resources of his or her supplier.

Users who are members of the same organizational community as the supplier – for example, an MSU student and the MSU computing center – are internal customers. The relationship between the student and the host is a primary one. A

user from a different university who wishes to become a customer of one of the network computing centers, e.g., the one at MSU, is an exchange customer. The supplier – in this case, the MSU computing center – serves as a secondary host to an exchange user.

This relationship between a user and his or her computing center extends to the mechanics of network use. Network exchange accounts are obtained at secondary hosts by the customer's primary host. The primary hosts have direct control over the account acquisition process. Each customer with at least one network exchange account pays his or her own computing center for all services received from both primary and secondary hosts at rates determined solely by the primary computing center. The perception of the user is that he or she is dealing, administratively, solely with his or her own center.

Almost anyone with a valid primary account may apply for a secondary account. In the case of students, this is normally the responsibility of course instructors. Individuals not affiliated with any university and having adequate reason to have an account at any one university may either obtain an exchange account or independently open separate primary accounts.

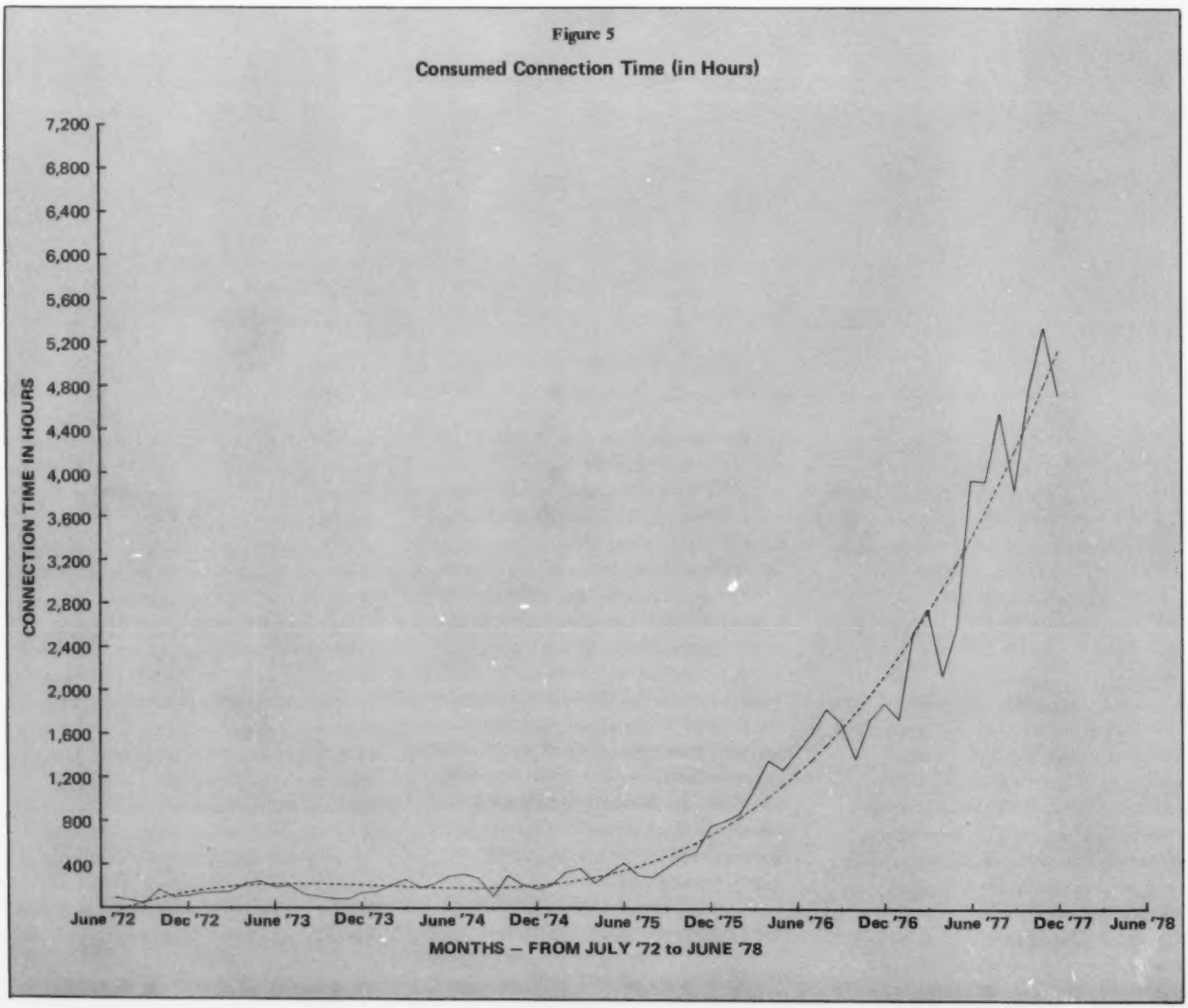
Regardless of how users obtain host accounts, they may use the network. Some network users have exchange accounts, while others have separate primary accounts. Still others are individuals who have elected to swap accounts outside their own institution.

Pricing and payment mechanisms. The pricing of services is rather straightforward. Suppliers set prices as they see fit. Each of the three computing centers charges for all use of its computing facilities. In every case, these charges are based on specific rates for the various services offered. Secondary hosts may – and one does – have a unique set of rates for exchange account users.

Primary hosts have the option of surcharging their exchange clients. Although no host has yet done this, it appears likely to occur in the near future. The purpose of the surcharge is to cover the primary host's retailing expenses, such as consulting, providing user rebates, preparing network-related documentation, and billing.

Among the host charges are network

Figure 5



EDUNET NEWS

Number 7, Spring 1978 ISSN: 0146-1788 Editor: Paul S. Heller

EDUNET Resources Highlight NCECS Workshops

EDUNET resources were demonstrated to 57 faculty members representing a wide spectrum of academic disciplines at two workshops sponsored by the North Carolina Educational Computing Service (NCECS). Twenty-five faculty members with interests in international education attended the November 18–19 North Carolina Southeast Consortium for International Education (NCSCIE) workshop at NCECS. Another 32 faculty members with interests in biology and health sciences attended a December 9–10 Biology and Health Sciences Workshop at NCECS.

The NCSCIE group consisted of faculty members representing economics, history, English, mathematics, biology, German, French, political science, religion, geography, sociology, and anthropology. To provide interesting and academically stimulating materials that would meet the disparate needs of such a heterogeneous group presented NCECS with a challenge. EDUNET Resources helped meet that challenge, with many of the demonstrations generating lively discussions. Participants accessed materials at Dartmouth, Notre Dame, Minnesota, MIT, Wisconsin, and Stanford. Programs that were found particularly interesting include: the Stanford Writing Programs; the Dartmouth programs in foreign languages, geography, anthropology, graphics, social science, and economics; and the Minnesota presidential election simulations. Of these, Dartmouth's IMPRESS, TRIBUNAL (a game that teaches historical lessons dealing with the French Revolution), and LIFEWAYS*** (an anthropology game about life-styles that provides an analysis of the user's cultural preferences) attracted attention. Wisconsin's TELEMAIL system also generated considerable discussion. SAGE, a component of the Stanford Writing Programs that helps the user compose poetry, was a favorite of a number of the humanists in attendance.

The Biology and Health Sciences Workshop attracted faculty members from biology, health sciences, zoology, pathology, home economics, nursing, and physical education departments. Again, the wealth of EDUNET resources available provided a more than adequate selection of high-quality, interesting, and challenging computer-based instructional materials for review by this diverse group. At this workshop participants gained hands-on experience with Minnesota programs in patient simulations, epidemiology, menu planning, nursing, and biochemistry; Dartmouth programs in genetics, hormones, population, climate, and medicine; and Notre Dame CAI materials in botany, medical diagnosis, and ecology.

The workshops, which were each conducted in a large room with eight terminals, were characterized by a "five-ring circus" atmosphere. During several of the working sessions, participants were simultaneously accessing materials at four different EDUNET hosts as well as the local Triangle Universities Computation Center (TUCC). In order to give assistance to any particular user, one had to ask a more fundamental question than "What EDUNET resource are you reviewing?" One had first to ask, "What EDUNET host are you accessing?" Similar scenes – with many users accessing outstanding resources resident on computers around the country – will become, we believe, more and more commonplace as educational computing grows. NCECS is pleased to be among the pioneers in computer resource sharing at the national level.□

This is a preview of an article by Barry Berman that will appear in the NCECS Newsletter.

EDUNET— a Functioning Alternative

In the decade of the '60s, there typically was only one source of computing at a college or university – the central computer center. In the early '70s, minicomputers with vastly increased capabilities and decreased prices began to offer a cost-effective alternative for a number of applications. The advent of EDUNET provides yet another means of offering computing services – the network.

The roots of the networking concept in education and research go back to a major EDUCOM conference held in 1966, but it was not until October of 1975 that potential users were able to access the computers at three institutions willing to supply services to others – Dartmouth, MIT, and SUNY at Albany. Today, not quite two and a half years later, 11 institutions (see list of EDUNET suppliers) provide computing services to approximately 50 campuses throughout the country.

Statistical packages such as SPSS are available over the network from a number of different sources. The MULTICS operating system, data handling systems like IMPRESS, specialized graphics capabilities, and a wide variety of programming languages that may not be available locally, are also accessible through EDUNET.

All of these computing resources are catalogued on the EDUNET data base that runs under the SPIRES data base management system at Stanford. By accessing this on-line EDUNET directory containing information on more than 500 special resources, the potential user can easily learn whether a particular program or package is available, where it is available, and how it may be accessed.

EDUNET is organized as a central activity of EDUCOM's Planning Council on Computing in Education and Research. Each of the Planning Council's 23 member institutions has appointed an EDUNET liaison to serve as the contact for users at that institution who wish to use EDUNET. Moreover, the supplier institutions have made trial accounts available to all members, and many of the computing centers will allow other potential users to test resources at minimal charge.

Cont. on page 5

Institute for Advanced Computation Resources Available

The Institute for Advanced Computation (IAC), an interagency governmental body formed in 1971, is jointly sponsored by the Advanced Research Projects Agency of the Department of Defense and the NASA-Ames Research Center. Its charter specifies the development and distribution of advanced computational resources. The primary computing resource at the institute is the ILLIAC IV computer, a large parallel-array processor; the system support includes a wide variety of other computers and related devices. Remote access to this system is available through the ARPA network.

Access to these resources and the services of the institute is available to government-funded research organizations at cost. The institute's services include computer code development, code conversion for implementation on the ILLIAC IV, and advanced studies. Application areas currently active at IAC include seismic stress wave propagation, image processing, wind-tunnel simulation, global climate dynamic modeling, galactic evolution, plasma simulation, orbital determination, real-time signal analysis, and SEASAT Synthetic Aperture Radar studies. Concurrently, IAC is engaged in research in computer science and technology. These efforts include design studies for the next generation of computers, high-level advanced computer language development, technology validation for terabit optical archival mass storage systems, sponsorship of a summer fellowship program for computer science research, and system consultation in high-performance communication and computation environments.

At present, the institute has 115 members, including system designers, application specialists, engineers, and programmers. The institute's main offices are located at 1095 East Duane Avenue, Sunnyvale, California 94086; telephone 408-735-0635. For further information regarding the use of these facilities, please contact Paul Heller at EDUNET Central.□

```
SCHOOL = Dartmouth College;
NAME = PILOT;

SCHOOL = Stanford University;
NAME = PYLON;

SCHOOL = Stanford University;
NAME = Stanford Writing Programs;

SCHOOL = Triangle Universities
         Computation Center;
NAME = JOHNSON Chemistry Package;

SCHOOL = Triangle Universities
         Computation Center;
NAME = LEARNTSO;

SCHOOL = University of Minnesota;
NAME = An Exercise in Case Analysis;

SCHOOL = University of Minnesota;
NAME = BIOCHEMISTRY;

SCHOOL = University of Minnesota;
NAME = Code of Professional
       Responsibility;

SCHOOL = University of Minnesota;
NAME = Computer Generated Intent
       Questions;

SCHOOL = University of Minnesota;
NAME = Decisions Before Trial;

SCHOOL = University of Minnesota;
NAME = DEMGRAENS AND MOTIONS FOR
       JUDGMENT ON THE PLEADINGS;

SCHOOL = University of Minnesota;
NAME = Directed Verdicts; Summary
       Judgement and Instructions;

SCHOOL = University of Minnesota;
NAME = EPIDEMIOLOGY;

SCHOOL = University of Minnesota;
NAME = EVIDENCE - CASE BOOK VERSION;

SCHOOL = University of Minnesota;
NAME = EVIDENCE - McCormick Version;

SCHOOL = University of Minnesota;
NAME = FEDERAL RULES OF EVIDENCE;

SCHOOL = University of Minnesota;
NAME = Introduction to Experimental
       Methodology in Psychology;

SCHOOL = University of Minnesota;
NAME = Jurisdiction and Venue;

SCHOOL = University of Minnesota;
NAME = MIL-Minnesota Instructional
       Language;

SCHOOL = University of Minnesota;
NAME = OBJECTION;

SCHOOL = University of Minnesota;
NAME = Patient Simulations;

SCHOOL = University of Minnesota;
NAME = The Complaint;

SCHOOL = University of Minnesota;
NAME = The Defense Function;

SCHOOL = University of Minnesota;
NAME = The Use of Intent in TORT;

SCHOOL = University of Minnesota;
NAME = Tort Law - The Sprague Case;

SCHOOL = University of Notre Dame;
NAME = BIOLOGY;

SCHOOL = University of Notre Dame;
NAME = EARLY AMERICAN HISTORY;

SCHOOL = University of Notre Dame;
NAME = ENGLISH AS A SECOND LANGUAGE;

SCHOOL = University of Notre Dame;
NAME = PRINCIPLES OF ECONOMICS;

SCHOOL = University of Notre Dame;
NAME = REMEDIAL ENGLISH;

SCHOOL = University of Notre Dame;
NAME = THE HISTORY OF WESTERN
->       CIVILIZATION;
```

Lehigh to Evaluate Cost-Effectiveness of Outside Computing

"Make-or-buy" decisions are commonplace in industrial settings and constitute a class of problems well known to most students of business administration. With the advent of EDUNET, it has become possible for academic computer centers to consider "make-or-buy" decisions about the provision of computing services. No longer must all desired services be "made" (installed on the institution's computer); many computer services can be "bought" (obtained from an EDUNET supplier). This gives computer centers a degree of freedom in providing computing resources that was not previously available.

With support from the EDUCOM Planning Council, Lehigh University will examine several well-defined classes of service in order to determine which services can more effectively be obtained from an external source. Both services already being provided and those desired but not currently available through the computer center will be included in the study. The areas in which specific applications will be considered are shown in Table 1.

The study, which will be concluded by June 1978, has two major objectives:

1. It will evaluate the desirability, feasibility, and cost-effectiveness of

Cont. on page 3

```
Stanford Writing Programs  (Freshman English Tutorials)

  The Stanford Writing Programs consist of twenty-eight interactive
  PYLON programs designed to be innovative ways of teaching composition.
  The teaching programs cover a variety of skills and arts of written
  composition.  For example, there is a program on the use of the comma.
  There is another one on the use of details. Other programs cover the
  fallacies of relevance and the difference between concrete and
  abstract words in the context of the student's composing a poem.  Time
  spent on programs varies between ten minutes and thirty-five minutes,
  with the average at about eighteen minutes.  The programs were
  designed to appeal to a wide variety of students.  They are presently
  being used at Stanford and at other universities as well as on the
  high-school level.

  SEARCH KEYS: CAI, computer assisted instruction, poetry, composition,
               English, grammar, language, writing, punctuation,
               orthography, spelling, logic, validity
  TYPE: Interactive computer assisted instruction programs.
  LANGUAGE - SOURCE: PYLON (an interpreter written in SNOBOL).

  AVAILABLE AT: Stanford University
  AVAILABLE ON: IBM 370/168

  ACCESS: Log on to the Stanford computer (via TELENET if out of area
          code 415).  You must not be in SPIRES, so issue the command
          'exit' if your account automatically puts you in SPIRES.
          Then type 'exec from $pylon public'.  This will start the
          programs and prompt you for the name of the module you want
          to run.  The names are mostly common spices which must be
          prefixed with the '$' symbol.  Try $sage for a start.  Others
          are $sugar, $clove, $cinnamon, etc.  For a complete list of
          the modules, issue the command 'use pylon$library public',
          and then 'list' when WYLBUR prompts you following the 'use'
          command. To stop the programs you can answer 'no' to one of
          the prompts 'Do you want to continue?', or simply type
          'logoff clear' to stop the programs and disconnect yourself
          from the Stanford computer.
  DOCUMENTATION: In WYLBUR, 'use pylon$library public' and 'list'
  SUPPORT LEVEL:
     -None Specified-
  CONTACT: Ellen Nold
          Communications Project, School of Engineering
          Stanford University
          Stanford, CA 94305
          Phone: (415) 497-2573
  CONTACT: Gerald R. Lathrop
          SCIP, Polya Hall 156
          Stanford University
          Stanford, CA 94305
          Network Mail: GA.GRL
          Phone: (415) 497-4352
```

CAI on EDUNET Data Base

The EDUNET Resources data base provides current information on a wide variety of software services. Instead of publishing a single catalog that would soon be out of date, *EDUNET News* will, in this and future issues, list the resources that relate to a particular topic.

A partial listing of computer-assisted instruction (CAI) packages is printed on page 2. For greater detail on any of these, you may sign on to Stanford and scan the data base yourself. When you do so, you will obtain descriptions such as that printed on the left-hand column of this page.

Information on how to conduct such a search can be obtained by contacting EDUNET Central. □

Addition to the EDUNET Staff

Rodney M. Mebane, a recent graduate of the Annenberg School of Communications at the University of Pennsylvania, has joined the EDUNET Central staff as a research assistant. He will be responsible for the development and organization of documentation on EDUNET resources as well as for providing assistance to EDUNET users to facilitate their use of these resources.

Rod received a B.A. in political science from Swarthmore College and was later engaged in public policy planning in Washington, D.C. At the Annenberg School, he completed a master's degree program in institutional communications.

He will participate, along with other members of the EDUNET staff, in many Planning Council activities. His particular interests include network use promotion within the social science disciplines and government policy as it relates to networking and telecommunications. □

Cont. from page 2

utilizing external services in specific application areas. The evaluation will include the impact of (a) the quality of basic services (account initiation, documentation, output distribution, etc.), (b) telecommunications and technical facilities, and (c) supporting services, including consulting and error reporting. Evaluation of feasibility will focus on financial, technical, and management considerations.

2. It will define, review, and classify the areas in which it would appear to be cost-effective to acquire services from an external source.

Interim reports from Lehigh will be disseminated by EDUCOM and will provide useful short-run results that should have broad applicability to other institutions. □

Table 1

Services not now available
Access to specific computing systems (e.g., IBM 370)
Large central memory
Selected languages (e.g., APL)
Commonly used data bases
Advanced interactive graphics
Experimental instructional packages
Unique instructional software
Services available but eligible for external acquisition
Moderately large central memory
Specialized computers
Major applications packages
Services that avoid local conversion

EDUNET NEWS

Spring 1978 Page 4

Liaisons Report EDUNET Activity Increasing

The second EDUNET liaison representative meeting was held in Kansas City, November 10–11, 1977, following the ACM SIGUCC meeting. Many of the liaisons reported increased EDUNET activity at their institutions, and this increase is reflected in the many articles about EDUNET that have appeared in local computing newsletters.

Dartmouth College and North Carolina Educational Computing Service (NCECS) reported that they are using demonstration accounts at other schools. Barry Berman, from NCECS, has been giving demonstrations and workshops across North Carolina. MIT is beginning to work on a video package about MULTICS.

An afternoon working session provided everyone with the opportunity to work on materials such as resource fact sheets that will be used to inform users about the services offered by EDUNET institutions. Each person also worked with the EDUNET data base and had an opportunity to try out resources offered by other schools. Several liaisons opened new accounts at other EDUNET institutions. □

EDUNET—What It Means to the Potential User

A math professor at Duke University is using MACSYMA at MIT. A psychology professor at the University of Wisconsin–Eau Claire is using EXPERSIM at North Carolina. Faculty members at Mills College are testing instructional materials at both Dartmouth and North Carolina. A statistics class at Carnegie-Mellon University is using LIDA at Yale, while a CMU philosophy professor uses logic programs at both Dartmouth and Notre Dame.

Faculty members and students throughout the country now have access through EDUNET to computer resources not available locally. Access to EDUNET suppliers (see list) is possible via long-distance phone calls and Telenet, a public packet-switched data communications network. In cities with Telenet access numbers, users can simply dial a local phone number, request the desired EDUNET host, and start to work. Telenet communication costs will be billed to the EDUNET supplier. The EDUNET supplier bills users directly for both communication and computer costs.

The EDUNET Central staff is available to help all users search the EDUNET data base and to locate particular resources or programs on any given topic. When the appropriate programs are located, EDUNET Central will:

- establish a user account at the desired EDUNET supplier
- provide rate information
- give log-on instructions
- supply any other necessary documentation

EDUNET liaisons located on Planning Council campuses will also help users to gain access to needed resources.

Call the EDUNET HOTLINE for these services or any additional information. □

EDUNET Suppliers

Cornell University
Dartmouth College
Massachusetts Institute of Technology
University of Minnesota
University of North Carolina (TUCC/NCECS)
University of Notre Dame
Rice University
Stanford University
State University of New York at Albany
University of Wisconsin, Madison
Yale University

EDUNET Want Ads

One of the uses of the EDUNET HOTLINE has been to receive inquiries from persons looking for particular programs, packages, or types of service. EDUNET Central has searched the EDUNET data base and has also broadcast these requests via TELEMAIL to all Planning Council schools. We would like to pass these requests on to all readers of *EDUNET News.* If you have a resource that might meet some of these needs, please call or write EDUNET Central, and we will forward the information to the indicated person. This will enable us to know how well we are helping people meet their needs.

In response to last issue's ads, the University of Wisconsin at La Crosse was able to provide Notre Dame with information about a program for Flanders Interactive Analysis.

Current requests are as follows:

Population Research Steve Graham of the University of Washington is looking for population research materials in addition to those available at Princeton, Wisconsin, and Michigan.

Performing Arts The University of Illinois is looking for administrative programs that apply specifically to the performing arts. Particular programs desired include accounting, inventory, payroll, and scheduling. Programs would be transported to a minicomputer or to the university's CYBER system.

Cont. from page 1

Facing increased computer demand in a time of general financial pressure, the cooperative arrangements embodied in EDUNET have provided institutions of higher education with the means to substantially expand the range of computing services available to their faculty members and students. □

Although the Planning Council has a limited life and membership, its purpose has always been to make the benefits of its activities generally available to the higher education community. The Council is now actively involved in developing a long-term "business plan" that proposes alternative arrangements for providing continuity for EDUNET after the Council is disbanded in June 1979. As a step in the direction of an expanded organization, the Policy Board of the Planning Council has approved a new membership category — Associate Member. Associate Members will be able to participate in most of the activities of the Council — they can be included in EDUNET as suppliers, participate in policy-setting discussions, and take advantage of EDUNET facilitating services.

ETS Provides Services to Law Schools

For over 25 years, Educational Testing Service (ETS) has provided a wide range of services to law school admissions offices through the Law School Admission Council. These services include preparing, administering, and reporting the results of the Law School Admission Test, summarizing the contents of applicants' undergraduate transcripts, preparing and distributing a variety of related publications, conducting research on subjects of interest to the law school admissions community, and providing other services in support of these activities. One of the by-products of these services is a large accumulation of information about law school applicants.

As part of an experimental project, seven law schools have been provided with both computer terminals and software to retrieve this information in ways useful to the day-to-day operation of an admissions office. This system, called the Law School Interactive System (LSIS), permits law school admissions personnel to

- enter information to update a candidate's records, using codes that indicate the admission status of the candidate
- define subsets of the total candidate population using one or more selection criteria
- request a list of the candidates identified in a previously defined subset
- request statistics on the candidates identified in a previously defined subset
- view a complete set of information for a particular candidate

A law school may augment the information collected by ETS with information that is unique to that particular school. The system permits an additional 11 codes that describe the status of the applicant from the filing of an application form at the law school through registration as a law student.

The experimental LSIS system has been developed to test the feasibility of providing admissions officers with direct access to data stored at ETS that are relevant to their operations. The intent is to test the technical feasibility of this approach as well as to verify the operational usefulness of this information on a day-to-day basis. The law schools participating in this experiment will perform an evaluation of the system for the Law School Admission Council later in the spring of 1978.

For more information, contact Mr. Tony Glockler, Educational Testing Service, Princeton, New Jersey 08540; telephone 609-921-9000. □

EDUNET Hotline

Call 800-257-9505 for help

The EDUNET HOTLINE has been used extensively for access to current EDUNET information since its installation. The toll-free number may be used from anywhere outside New Jersey. The staff at EDUNET Central has been busy answering questions about account information, available resources and services, documentation, and other EDUNET matters. Official hours are from 9:00 a.m. to 5:30 p.m., Eastern time. If you try after 5:30 p.m., it is possible but not guaranteed that someone will answer.

Uses of the HOTLINE have included the opening of guest accounts for liaison representatives to use at other schools, discussing the use of CAI at law schools (see *EDUCOM Bulletin*, Summer 1976), supplying information on communications costs, answering questions about accessing new suppliers, and other similar topics.

The EDUNET Central staff will either answer your questions or put you in touch with someone who can.

It's toll free, so call!

Correspondence

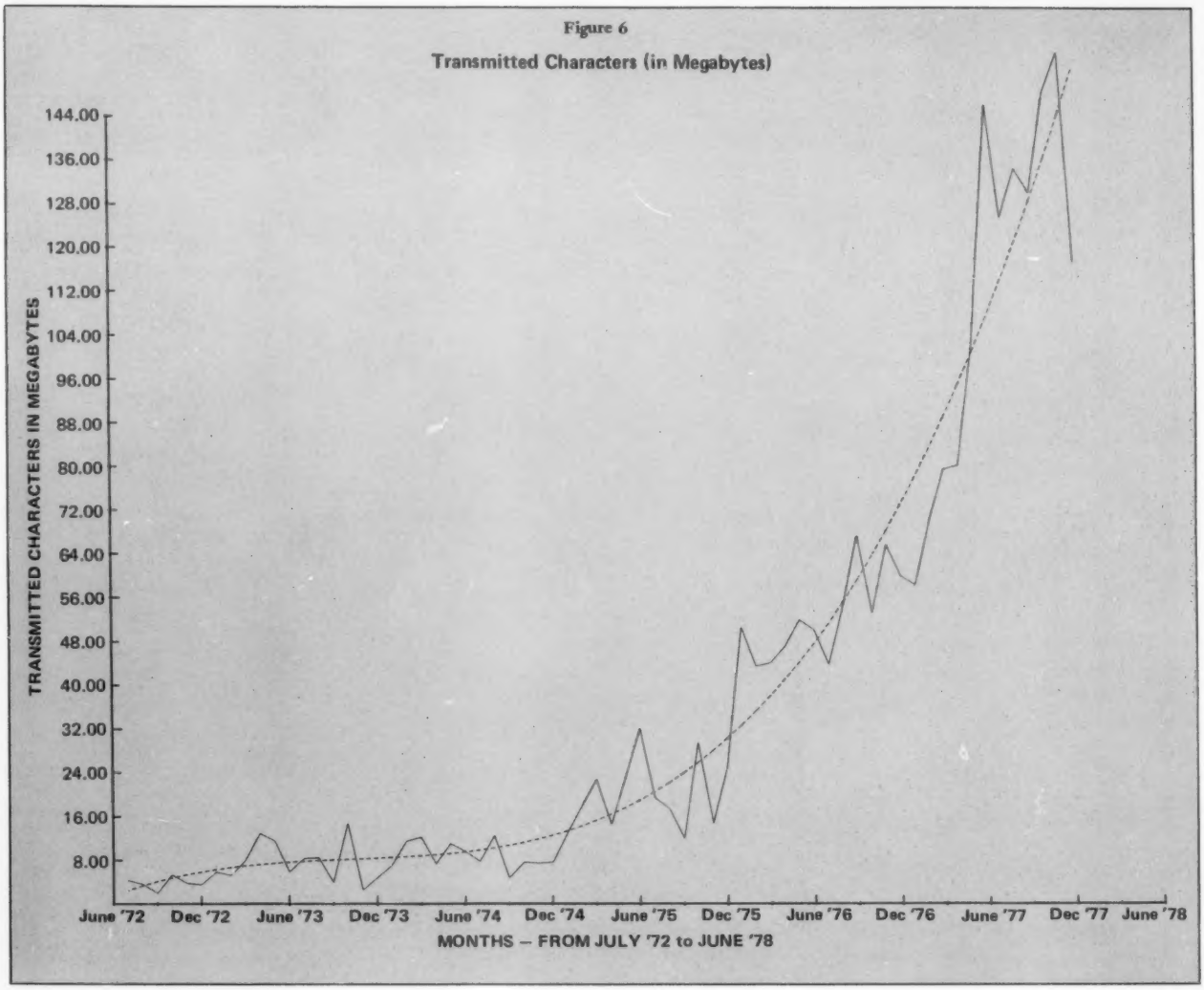
To submit material or obtain further information related to issues discussed in the *EDUNET News*, please contact:

Paul S. Heller
EDUNET News
EDUCOM
P.O. Box 364
Princeton, New Jersey 08540
Telephone: 609-921-7575

EDUNET NEWS
EDUCOM
P.O. Box 364
Princeton, New Jersey 08540

NON PROFIT ORG.
U. S. POSTAGE
PAID
Princeton, N.J. 08540
PERMIT No. 373

Figure 6



connect time for interactive use and the equivalent of a card-read charge for batch input. The money collected for these charges can be considered to offset the network's cost to the respective universities.

By agreement, the payment for services exchanged between suppliers is also straightforward. The flow of computing resources between network hosts is measured, at the gross level, in computing resource dollar units. Any changes in the rates for services that flow through the network must be announced in writing to all other suppliers 30 days in advance of the effective date.

The Merit hosts have agreed that the differential flow of computing resources between them will be reconciled only if the net balance – produced by all of the exchange users – between any two institutions exceeds $20,000. This limit was not exceeded until the 1976–77 fiscal year. In that year a $40,000 payment was required between one pair of institutions. These interhost transactions are essentially wholesale exchanges and are not of direct concern to individual users.

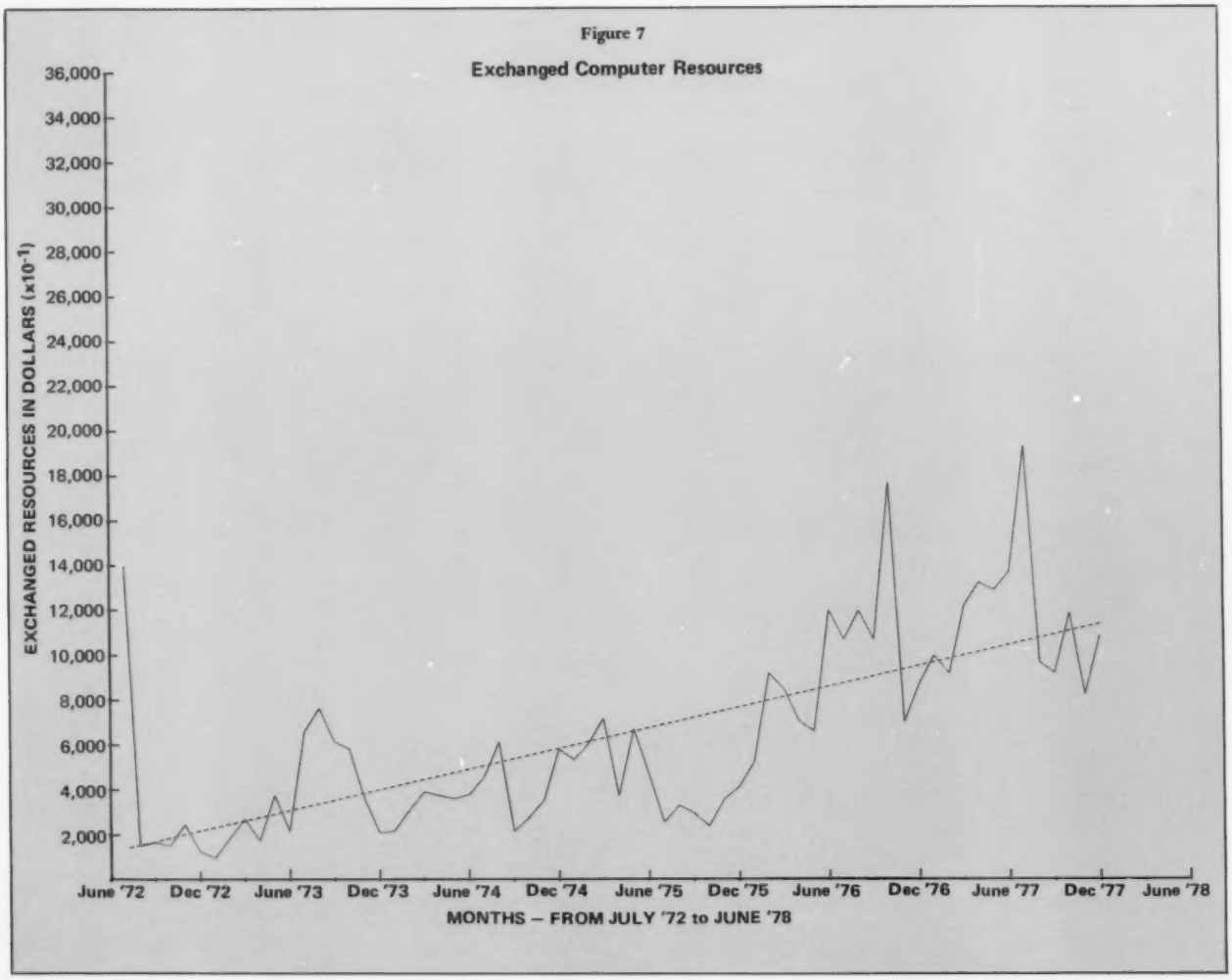
Network Usage

The most important indicator of a network's success or failure is how much and in what way the network is used. The technological, organizational, and operational structures of Merit have successfully stimulated use of the network. Total telecommunications traffic on Merit has grown by more than 100% each year, and growth in all areas has shown a continuous, at times dramatic, increase.

Measures of usage. Two major measures of network usage are assessed and catalogued on a monthly basis: network transmission activity (physical usage) and host resource utilization activity. One purpose of reporting these statistics is to develop a record of network use as a function of time. This is done by maintaining a set of time series, based on monthly statistical summaries, that describe total network traffic and resource exchange. Three of these time series relating to network transmission are:

- *successful network connections* – the total number of connections successfully opened in a given month
- *consumed connection time* – the total number of hours during which all successfully opened connections remained open during a month

Figure 7



- *transmitted characters* – the total number of characters (eight-bit bytes) transmitted over all successfully opened connections in a month, expressed in megabytes

Plots depicting each of these time series are shown in Figures 4–6. The horizontal axis in each plot represents a six-year span beginning in July 1972, broken down into six-month intervals. The scale on the vertical axis varies from one plot to another. In each plot the solid curve represents actual monthly usage data and the broken line is a third-degree regression curve through the data points.

The network has matured appreciably since it began in 1972, as the usage curves illustrate. New services have been introduced and existing ones improved. Certainly, the 1978 network is much more powerful and convenient than the 1972 network was. One of the few characteristics that has not changed is Merit's basic three-node structure.

The impact of the network's growth through various stages is reflected in the time series data. The importance of the statistics can be better appreciated in light of the major developments in the network's history. Merit first offered users host-to-host interactive service between two nodes in July 1972. This service was extended to include the third node in October 1972. In October 1973, the original 2000-baud internode telephone lines were replaced with the current 4800-baud service. In October 1974, batch service became available between two of the nodes; it was not extended to the third node until January 1977. Hermes service was initiated on a limited basis at one node in September 1975 and was gradually extended to the other nodes. By May 1977, Hermes service was fully developed at all three nodes. The Merit-Telenet internetwork tie started in December 1976.

The pattern of Hermes usage serves as a good indicator of the network's more recent growth. Table 1 lists the hours of Hermes use per month during 1977. The times reported are total usage hours; hours of access through Hermes to a node's local host are included in these figures.

The other measure of network usage is concerned with the amount of host resource utilization activity. One of the time series included in this measure reflects the official interhost exchange in accordance with the previously described network resource exchange agreement. Each month all three computing centers report the dollar amount of billable network-related computing performance purchased by exchange users. This time

series is shown in Figure 7. The broken line represents a linear regression curve through the data points. Again, the time scale covers the period from July 1972 through December 1977.

Merit maintains records for two other network transmission time series and one more utilization time series:

- *number of network users* – the number of different computing IDs successfully opening connections
- *transmitted packets* – the total number of packets transmitted over all successfully opened connections, expressed in kilopackets, with each packet containing up to 240 bytes of data if necessary
- *utilized host resources* – the total job cost accrued to all jobs, both interactive and batch, that utilize the network

Annual totals for these three time series and those described in Figures 4–6 are indicated in Table 2.

Table 1

1977 Hermes Usage in Hours*

Month	From Ann Arbor	From Detroit	From East Lansing	From Telenet	Total
January	275	893	–	87	1255
February	513	1397	–	143	2053
March	405	1521	–	201	2127
April	446	554	–	165	1165
May	666	1018	286	225	2195
June	716	1288	1154	371	3529
July	805	1249	1069	411	3524
August	979	1682	953	531	4145
September	724	1581	688	439	3432
October	1410	1610	801	522	4343
November	1374	1919	968	657	4918
December	1076	1759	812	598	4245

**There are four Telenet ports, sixteen dial-up ports, and one hard-wired port in Detroit; eight dial-up ports in Ann Arbor; and four dial-up ports in East Lansing.*

Significant Issues in the Merit Experience

Network technology. One major accomplishment was the successful design and development of Merit's packet-switching network. This form of computer communication was first developed and brought to the public's attention by the pioneering efforts of the participants in the well-known ARPA network. Merit shared in some of these early efforts, but elected to evolve its own technology. While there are many similarities between the ARPA and Merit systems, there are also important differences. Perhaps the most significant of these is the way in which hosts are coupled to the network. The ARPA approach uses a bit-serial link, while Merit has parallel data-transfer interfaces.

The method by which Merit's CCs were to be connected to their hosts was given considerable analysis. It was decided to provide host interfaces that would

1. require a minimal amount of direct extra-host software support
2. transfer information efficiently and rapidly
3. utilize most, if not all, of the power of the host's input/output architecture

These attributes were emphasized at the possible expense of interface hardware simplicity and cost. Furthermore, it was decided to allow each host site to divide its local support software on either side of the hardware interface in the most advantageous way possible. This meant that a common software interface had to be precisely defined within the CCs.

The flexibility incorporated into the system through the host interface decision continues to be appreciated. One of the principal benefits of this decision is the ability it gives the host to view its CC as many logically equivalent devices, thus eliminating the host's need to multiplex concurrent users onto one device through its software.

The buffer concept. The $20,000 exchange-payment buffer previously mentioned is significant in several aspects. Its most obvious advantage is in promoting network usage by allowing hosts to obtain a certain amount of network service for their users without having to

Table 2

Network Statistical Summary

	1972–73	1973–74	1974–75	1975–76	1976–77	1977–78*
Transmission activity						
Number of users	$ 1,176	$ 1,716	$ 2,287	$ 4,596	$ 9,430	$ 7,275
Number of connections	9,065	11,959	18,351	38,282	87,546	77,581
Transmitted kilopackets	1,831	2,650	4,083	8,476	19,829	18,369
Connect time (in hours)	1,696	2,101	3,303	9,575	25,813	27,116
Transmitted megabytes	72	102	171	405	880	811
Utilization activity						
Exchanged	$35,245	$51,981	$58,463	$ 67,242	$137,445	$ 68,906
Host utilization	NA	NA	NA	$170,792†	$331,774†	$236,265†

**Six-month figures, July–December 1977*
†Includes UM and WSU data only

Interuniversity agreements now reaching a final state of completion will require that the hosts pay one another for all purchased interuniversity services.

provide any service in return. This concept enabled network usage patterns to form under the least threatening of circumstances. One of the primary impediments to usage stemmed from university management's initial reluctance to encourage use of resources at secondary hosts. This reluctance can, in large part, be traced to the fact that prediction of "balance of payment" outcomes in a network environment is very difficult, and budgeting for them in advance is virtually impossible without guidelines derived from actual experience. Having kept a detailed check on usage in the buffer environment, the Merit staff is now able to make knowledgeable predictions regarding the direction of any real cash transfers.

Cash transfer. Historically, the Merit hosts have not had to pay one another for exchanged network services because they did not exceed the buffer limit. As previously stated, a cash settlement of nearly $40,000 was made for the first time in fiscal year 1976–77. Interuniversity agreements now reaching a final stage of completion will require that the hosts pay one another for *all* purchased interuniversity services. The Merit participants believe that this is the only sensible way of doing business once a network's initial administrative hurdles are solved.

Network services. The Merit participants realized very early that user satisfaction was a key factor in the growth of the network. As a result, they have worked hard to provide high-quality user services. Users are kept well informed on the state of the network in terms of both resource availability and documentation for network capabilities. The network shares the responsibility for the distribution of system documentation throughout the user community, maintains on-line information files at all three hosts, and manages a computer conference for network users. Merit also disseminates information relevant to the design and operation of the communications subsystem and interfaces.

Each participating university is required to maintain and distribute its local documentation and is responsible for issuing notices reflecting any significant changes. The three computing centers exchange documentation and maintain copies of the manuals of the other host systems for their local users. User consultation services are provided by staff members at each computing center as well as by the Merit offices.

Expansion. As noted, network access has been expanded to accept terminal input from any Telenet entry point. Although current policy permits only a limited marketing of Merit resources, the Telenet connection leads to more widespread exposure. It is Merit's task to deal with and define the implications stemming from this exposure. How could Merit function as a resource for other computing communities and networks? What is Merit's responsibility to these new users in areas such as system and resource documentation – in fact, throughout the spectrum of user support?

Naturally, certain details of expanded operation were worked out before the Telenet connection was actually established. Account control, for example, is the direct responsibility of the individual hosts. Charges are also set by the three computing centers. In every case, these charges are based on standard rates for the various services offered. Each computing center also charges for network use, which involves all data processing necessary to transport information over the networks. Network charges are based on the duration of the network connection and computed in accordance with the published rates. The current surcharge for a Telenet-to-Merit connection is $4.80 per hour.

Additional means of expansion are currently being considered – not only in terms of feasibility, but also in terms of appropriateness. The development of the internetwork tie represents a challenging technical exercise that offers substantial long-term rewards. The Merit organizational hierarchy is actively contemplating how best to maximize these rewards and define Merit responsibilities toward that end.

Plans for the Future

Enhancement of both the quality and quantity of Merit's communication services remains a primary objective. Planned improvements will simplify user control of network resources, speed data transfers, and expand the range of network capabilities. Such developments are a direct result of experience gained from network operation.

One current project focuses on developing a more powerful internetwork link. Merit's existing Telenet tie is a limited one. This linkage will be upgraded to support an X.25 synchronous gateway. Subsequent plans include working with non-Merit hosts to provide a larger community of users with some of the same interhost services now enjoyed within Merit. Additional projects under consideration entail the development of gateways to TYMNET or yet other networks.

The present three-university network was planned as the first step in establishing a statewide higher-education network. In 1973, MICIS was expanded to include the remaining four-year institutions in the state. If Merit services

are similarly extended, the full range of Michigan's computing resources would be available to more of the students, teachers, and researchers in the state at a reasonable cost. In fact, without Merit, many Michigan institutions will not be able to provide access to modern, sophisticated resources similar to those made available through the network. There are three principal ways to expand Merit services to these colleges and universities.

Direct access. Other institutions may gain direct access to the Merit network through one of the host computing centers. Oakland University and some Detroit-area community colleges, for example, have used the network by directly accessing WSU's computing center. While such users must, of course, pay the usual rate for host and network services, no additional equipment is necessary to expand network access in this fashion.

Additional communication computers. Institutions with their own large host computers — such as Western Michigan University, an institution currently committed to joining Merit if expansion funding is obtained — would come into the network by acquiring their own communications computer. Each such new host institution would become both a supplier and a consumer of network resources.

Network satellite. The use of a network satellite is planned in order to provide services for institutions with limited local computing capacity or those too far removed from the current hosts to obtain convenient direct access. The satellite differs from a communications computer in that it will serve users directly via terminals, a card reader, and a printer, but it will not have a local host connection. Central Michigan University and Northern Michigan University are examples of institutions for which a Merit satellite would be ideal.

Conclusion

Merit began as a project to determine whether it was possible to develop and operate a resource-sharing network involving several independent university computing centers. There is no longer any question that this is technologically possible. Furthermore, the network can be operated reliably and effectively to provide service on a continuous basis. Administrative issues relating to the exchange of computing resources among the network's independent host computing centers can be and continue to be resolved.

It is evident that operating a university resource-sharing network involves much more than providing the physical communication facilities. In this sense, Merit substantiates many of the conjectures about networks made by the NSF/EDUCOM study reported in *Networks for Research and Education.* It is important to recognize that these problems can be solved and that the results are worth the effort. □

Employment Exchange

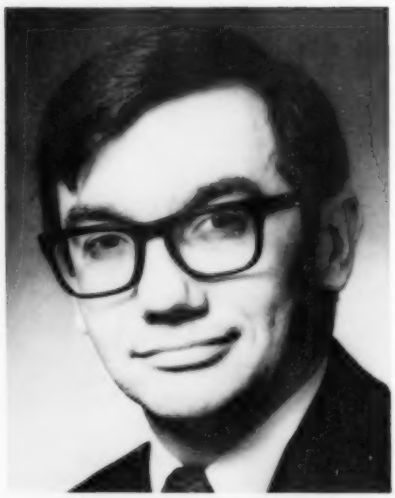
COMPUTATION CENTER DIRECTOR
Carnegie-Mellon University
Pittsburgh, Pennsylvania

Carnegie-Mellon University is seeking a director for its computation center. The computation center provides information processing services to educational, research, and administrative users throughout the campus. The director reports to the Vice-Provost for Information Services and has the management responsibility for operations, systems programming, and engineering activities such as the installation of new computing equipment.

Candidates should have broad management experience, in-depth technical knowledge, and a thorough understanding of the complexities of university administration. A Ph.D. is desirable but not required. Salary will depend on qualifications and experience. Send curriculum vitae to the Chairman of the Search Committee, Dr. John W. McCredie, Vice-Provost for Information Services, Carnegie-Mellon University, Pittsburgh, Pennsylvania 15213. Carnegie-Mellon is an equal-opportunity, affirmative-action employer.

The Coming Challenge of Campus Computation

James C. Emery



James C. Emery is President of EDUCOM and Executive Director of the Planning Council on Computing in Education and Research. Dr. Emery served as conference chairman for the EDUCOM Spring 1976 Conference, "We CAN Implement Cost-Effective Information Systems NOW." Prior to joining EDUCOM in 1975, Dr. Emery was a professor at the Wharton School of the University of Pennsylvania. He holds a Ph.D. and an S.M. from MIT, and a B.S. from the University of Arkansas.

Introduction

We are everywhere reminded of the challenges facing higher education. Demographic and economic trends are both forcing changes. Institutions that respond widely to the new environment are likely to thrive in spite of the difficulties, while those that attempt to persist in their old ways may find that their problems will increase.

Campus computing is, of course, affected by financial stresses and shifts in the student population. In addition to responding to these general currents, campus computing must also adapt to a rapidly changing technology that presents new opportunities as well as new challenges.

Technological Changes

The most obvious change in technology is the continuing dramatic reduction in the cost of electronic circuits. At the basic circuit level, costs decline by an average of perhaps one third each year. Technological advances are passed on to the user rather quickly in the highly competitive and innovative minicomputer industry, so that price reductions of 20–25% per year are not uncommon. The mainframe manufacturers are not immune to this competition, and as a result are passing on substantial price reductions to their customers. Electromechanical devices – such as terminals, printers, and auxiliary storage devices – benefit from advances in electronics and recording technology as well as from their expanding production volume. As a result, they too have exhibited substantial price reductions over the years (albeit not so great as those of the central processor and primary storage).

Communications technology continues to show worthwhile advances, due in part to its increasing use of digital circuit technology. Communication costs, however, are to a large extent determined by wage rates and the cost of materials subject to inflationary increases. Thus, although communication costs are likely to show some price reductions – one estimate places the average annual reduction at 11% – they will nevertheless increase relative to the cost of raw computing power.

Implications of Technical Advances

One implication of these technological trends is quite obvious: the cost of hardware needed to perform a given set of tasks will continue to decline, both in absolute terms and (especially) relative to personnel costs. This is abundantly clear from even a simple extrapolation of current trends. Assume, for example, the following:

- A computer center's current costs are one third hardware-related and two thirds personnel-related.
- Hardware costs will decline at an average rate of 15% per year.
- Personnel-related costs will increase at an average rate of 4% per year. (This projection assumes improvement in productivity to partially offset inflationary increases in salaries and benefits.)

Under these conditions, the cost of computing in future years will change as shown in Figure 1. It can be seen that hardware costs become less and less significant – declining in five years to 15% of the base year total cost, and to less than 7% in ten years. Total costs remain essentially stable over the 10-year period as reductions in hardware costs nearly match inflationary increases of personnel costs. As hardware costs become smaller, however, the rate of increase of total cost begins to approach the rate of increase of personnel cost.

It is interesting to observe the effect of keeping real computing expenditures constant in the face of inflation. Suppose that the total computing budget increases at a 5% inflationary rate, while other costs behave in the way assumed in the above example. Under these circumstances, the "disposable surplus" – the difference between the total computing budget and the cost of maintaining present services – becomes quite significant, as shown in Figure 2. For example, in five years the "surplus" grows to about one fourth of the total cost, while in ten years it increases to over one third. These "surplus" funds could be spent to expand the services of the central computer center, or they could be used to add minicomputers or purchase external services over a network. In any case, significant discretionary funds would be available to be spent in a way deemed to be the most cost-effective use of resources (including, of course, support of noncomputing activities).

Although these costs are based on a simple model and assumed rates of change, the conclusions reached are not particularly sensitive to the values used as long as these values are kept within reasonable ranges. Because of rigidities in "fixed costs," the actual costs budgeted by a computer center will not immediately reflect reductions in the market price of hardware. For purposes of analysis, however, opportunity cost (i.e., current market price) rather than accounting cost is the appropriate figure. To the extent that these costs differ, the difference should rightfully be viewed as a "sunk cost" attributable to earlier periods. In any case, "fixed costs" change with time and will eventually reflect the reduction in the cost of hardware. Thus, the eventual effect of advances in technology is perfectly predictable; only the timing is at issue.

Because personnel costs are becoming

Figure 1

Hardware and Personnel Cost Trends

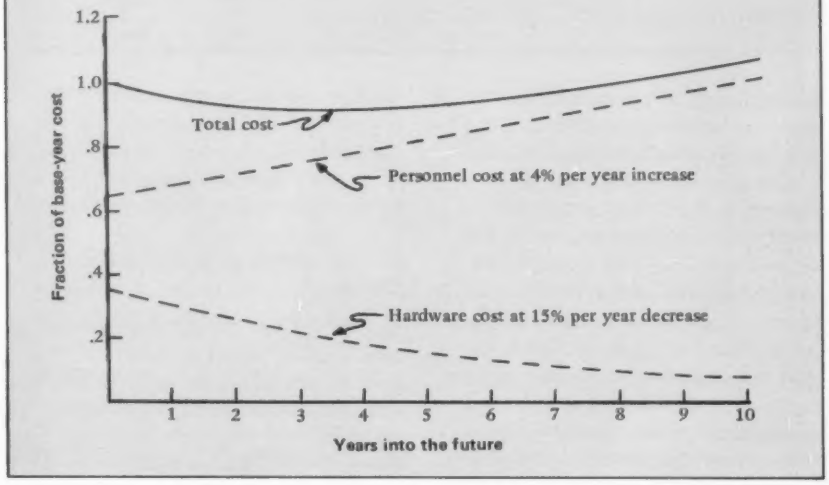
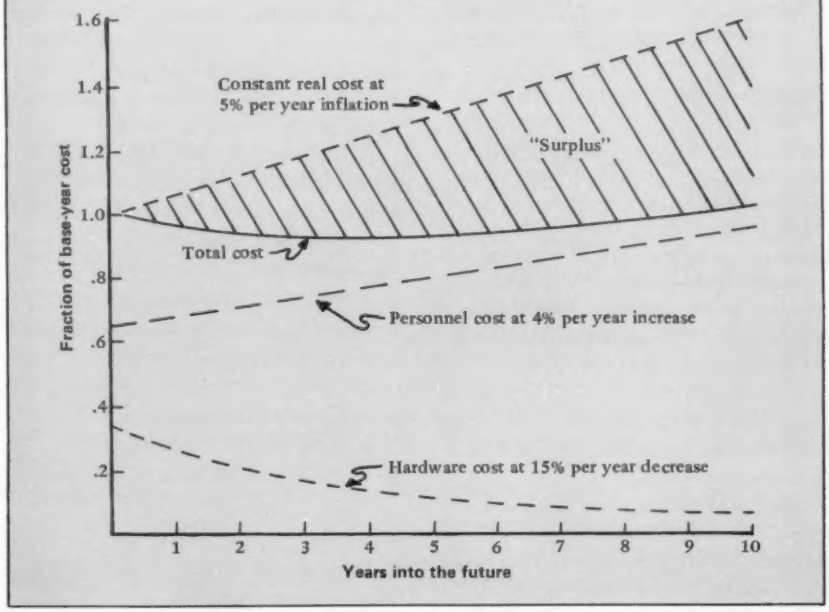


Figure 2

Growth in Discretionary Funds



Because personnel costs will almost always dominate any design alternative, the attractiveness of the central campus machine will depend primarily on the labor costs of providing a given service there versus the labor costs of providing the same service through a network or minicomputer.

the dominant cost component, it is important to consider ways by which they can be reduced. One approach is by increasing the productivity of the professional computing center staff through such means as programmer aids and on-line user services. Nevertheless, even if productivity increases completely balance inflationary increases in salaries and benefits – which is quite unlikely, given the relatively modest improvements in productivity made in the past – the personnel component would still dominate the total cost (e.g., 82% of base-year total cost in five years and 91% in ten years).

Another way of reducing personnel cost at the computer center is to have users take over more of the responsibility for design and programming of their own applications. To be sure, advances in user-oriented languages encourage such diffusion of responsibility. It is unlikely, however, that users could achieve greater productivity increases than could the professional staff (although there certainly may be other reasons why it might be desirable for users to do more of their own programming). Thus, actual personnel costs would not be greatly affected by the movement toward greater distribution of responsibility. In terms of formal budgets, it may appear that a saving has been made (because the cost of programming by users would often not be budgeted explicitly), but much of this saving would be illusory.

Sharing of software and data bases appears to offer the only significant opportunity for reducing personnel costs. Although resource sharing is never without costs, its cost is usually considerably less than the alternative of developing a tailor-made program or data base for one's own use. Resource sharing can be accomplished either by transporting the resource to be shared to a local computer or by accessing it over a network. Modest volume requirements can generally be met more economically via a network, while high-volume usage often favors local computing using transported software or data bases.

Role of the Central Computer Center

Given the trends in technology and the resultant shift in cost patterns, the question arises as to the best role for the central computer center at a college or university. The traditional computer center faces an external challenge from networks and an internal challenge from minicomputers. Rather than fighting a last-ditch battle to preserve the current role of the central facility, the managers of the computer center – as well as senior administrators of the institution – should try to choose a strategy that enables the institution to exploit emerging technology while maintaining continuity in the provision of their services.

A professionally competent central staff is essential to the efficient and effective use of minicomputers within the institution. The central staff can be enormously useful in such matters as

- hardware selection and acquisition (e.g., negotiating contracts, gaining purchase discounts through consolidation of requirements)
- selection and acquisition of proprietary and "free" software
- hardware and software maintenance (e.g., through consolidated contracts)
- standardization of languages, file formats, communication protocols, etc.
- installation assistance
- training

Similarly, the central staff has a vital role in dealing with a network, providing such services as

- assistance in locating desired services
- assistance in arranging access to desired services (e.g., opening an account with a network supplier, handling the supplier's invoice)
- technical consulting
- provision of communication services (perhaps through an internal network linking campus computing installations)

An obvious continuing responsibility of the central staff is the operation of a campus computer center. Despite the attractiveness of networks and minicomputers in providing certain services, it would be entirely premature to assume that the central computer could wither away over the next five to ten years without seriously degrading the computing services available to the institution. There are a number of reasons for this:

- Even if a concerted effort were made immediately to move all computing to minicomputers or networks, the transfer process would take several years to complete.
- Technological advances that reduce hardware costs of minicomputers also reduce the costs of large central machines.
- Even if one were to assume substantial diseconomies of scale in hardware, the hardware costs of the central machine would still constitute a declining (and eventually insignificant) fraction of total computing costs.
- Because personnel costs will almost always dominate any design alternative, the attractiveness of the central campus machine will depend primarily on the labor costs of providing a given service there versus the labor costs of providing the same service through a network or minicomputer. In some circumstances the central machine cannot compete favorably – for example, when the simplicity of a minicomputer reduces the cost of implementing a specialized on-line application, or when it is possible to satisfy low-volume needs over a network with little investment of personnel resources. On the other hand, certain classes of services can be provided more economically on a centralized broad-service machine. Powerful software, such as the more sophisticated data base management

systems and programmer aids, currently is often available *only* on big machines. Although minicomputer vendors continue to provide more powerful software, added software usually comes at a significant purchase or lease price; to this must often be added personnel costs associated with the maintenance of software packages. Currently most software vendors charge less for a software product shared from the central campus machine than they charge for the same package installed in multiple decentralized machines within the same organization. Thus, to the extent that "large" software packages are required, they will usually be cheaper to provide on a central campus machine than on multiple minicomputers. Nothing is likely to alter this situation within the next five (or even ten) years.

- Certain functions are inherently central in nature, and as a practical matter they must be performed on a central machine. A common data base shared among a wide variety of application programs and/or users must, for example, be centralized. Such applications are becoming increasingly common in the administrative area. Shared distributed data bases are exceedingly complex and risky and should be avoided in favor of a central data base unless overriding operational advantages can be gained; nothing on the five-year horizon is likely to change this fact either.
- Auxiliary storage still exhibits important economies of scale. Applications that require a very large data base thus favor a large machine with shared auxiliary storage devices.
- Users requiring "large" resources (hardware, programs, or data bases), but requiring them only sporadically, will generally find a central machine more cost-effective than a dedicated minicomputer (although a network resource may also be attractive in such a situation).
- A significant portion of the present cost of operating a central facility is due to the need to provide a wide range of services. As certain jobs migrate from the central machine (e.g., interactive student jobs move to minicomputers and highly specialized jobs are served via a network), the "base load" that remains can often be served very efficiently. The effect of such a migration on computing efficiency depends, of course, on whether the change results in a more favorable job mix or merely the same mix at a lower volume — and hence a higher unit cost. When computing requirements are reduced to a limited base load, hardware and software can be kept relatively stable, thereby reducing the system's programming staff and the penalties of disruption. Thus, the central machine can often be made extremely cost-effective for a substantial fraction of the campus computing load.
- When an institution chooses to offer services to external users over a network, this can normally be done best through a central facility (since external use often exhibits the same set of characteristics as the internal computing that is best done on the central machine).

Conclusions

What does all this mean? Despite the uncertainties of technological, economic, and demographic forecasts, certain patterns are beginning to emerge that will affect the strategies institutions should follow in providing computing services. The approach that appears to offer the most advantages is a hybrid strategy in which computing services are obtained from a number of different sources rather than solely from a central campus computer facility. Using this strategy, a given university would be likely to

- operate a central computer facility that serves "base-load" requirements very efficiently (typically with emphasis on batch computing) and provides a few specialized services for local and external users
- install minicomputer systems, under general guidelines established by an institution-wide computer policy board and coordinated through the central computer staff — in most cases, with the minicomputers tailored to specialized needs, emphasizing interactive application, rather than to general-purpose computing
- obtain an increasing fraction of its software from external sources — software vendors and other educational institutions — rather than developing it internally
- purchase specialized services from a variety of sources through a network; no single service is likely to be purchased in much volume, and the total network expenditures will usually constitute less than 5—10% of the total computing budget
- place increased emphasis on user services in order to assist users to take advantage of the best computing resources available regardless of source, concomitantly placing reduced emphasis on the operation of the central machine

In making these predictions about the probable future pattern of campus computing, I reveal my biases: this is the pattern that I think ought to be followed by a wide spectrum of institutions (including, incidentally, private sector firms and public sector agencies as well as educational institutions). The relative balance between the amount of computing obtained from different sources is likely to vary considerably among institutions, but the general approach will be quite generally adopted. The advantages of exploiting broader alternatives, rather than relying solely on a central computer center that tries to be as self-sufficient as possible, are so compelling that no institution facing tomorrow's challenges can safely ignore them. □

EDUCOM Seminars 1978

Planned on the format of the well-received 1977 Spring Seminars, the EDUCOM Seminars scheduled for 1978 will feature a tutorial approach to topics of current interest to EDUCOM members and others involved in computing in higher education. Each seminar will extend over one day, starting at 9:30 a.m. and ending around 5:00 p.m. During the morning, the seminar leader will give a tutorial presentation. The afternoon will be devoted to a general discussion among the participants, centered around a small case study or examples of functioning systems described by the seminar leader. The afternoon session also provides time for participants to exchange ideas and discuss problems of common concern.

To ensure adequate opportunity for individual participation, attendance will be limited to 30 participants per seminar. All participants will receive comprehensive seminar notebooks that will include a conceptual outline of material covered in the seminar, detailed examples of concepts and systems discussed, bibliographic references, relevant readings, case studies where appropriate, and illustrative screen formats or other system documentation where appropriate. Participants in seminars that cover currently available computer resources will receive information enabling them to use those resources and evaluate them for use on their home campuses.

All seminars are designed to help participants implement concepts discussed at the seminar upon return to their campuses. During seminar sessions, participants will work on individual plans for implementing seminar concepts, and where appropriate, may arrange for demonstration accounts at host computer centers in order to demonstrate specific computer resources to other faculty and staff members at their home campuses.

Program Information

Detailed program brochures for each seminar are available from the EDUCOM office. Copies have been mailed directly to Institutional Representatives, key people on member campuses identified by them, and selected individuals involved in computing in higher education. If you have not received a brochure for a seminar and would like to obtain one, please telephone the EDUCOM office. A brochure for the seminar of your choice will be sent immediately, and a place will be held for you in that seminar, if you wish, while you review the brochure.

The Pricing Computer Services seminar will help participants to

- identify principles underlying computer charge-out
- capitalize on the advantages of charging and minimize the disadvantages
- compare "funny money" and "real money" budgeting approaches
- design a price structure for computing services
- understand the use of priority and off-peak pricing, unbundled prices, quantity discounts, and transaction pricing
- consider the implications of federal government pricing rules
- deal effectively with pricing and budgeting in a distributed computing environment

The On-Line Admissions and Registration Systems seminar will teach participants how to

- determine their needs for computer-based and on-line admissions and registration systems
- identify their limitations for implementation of on-line computer-based admissions and registration systems
- compare alternative on-line systems
- design specifications for their own on-line systems
- implement an on-line system
- evaluate an on-line system after it is installed and running

The Simulation with the Computer seminar will teach participants how to

- judge when and at what level simulation should be used to help solve a particular problem
- select the appropriate simulation techniques for various kinds of problems
- evaluate the different types of simulation languages available for building models
- judge whether or not a particular experimental analysis that uses simulation has been designed in a reasonable manner
- compare simulation languages such as GPSS, SIMULA, and CSMP
- compare the general facilities of digital, analog, and hybrid computer systems built by DEC, EAI, IBM, and UNIVAC

At the Teaching Law with the Computer seminar participants will learn how to

- structure a course to take advantage of computer-aided exercises
- select the computer-aided exercises most useful for their own courses
- make arrangements to use the computer-aided exercises from terminals on their own campuses
- estimate total costs of using computer-aided exercises
- obtain terminals for student use
- evaluate student use of computer-aided exercises
- evaluate the advantages of preparing their own computer-aided exercises
- obtain assistance in programming and implementing computer-aided exercises
- obtain assistance in designing computer-aided exercises to take advantage of existing experience in instructional design

Seminar Locations

Each seminar has been scheduled in at least two regional locations. (See the back cover of this issue.) Additional locations may be scheduled if sufficient interest is shown. Institutional Representatives and other EDUCOM members who want to schedule a seminar for their campus or city should telephone Carolyn P. Landis at EDUCOM to arrange for the special session. Special sessions will be scheduled in all locations where at least 20 people will attend.

ANNOUNCING

A New EDUCOM Purchase Agreement

LEAR SIEGLER
VIDEO DISPLAY
TERMINALS
may be purchased
by member institutions
at the prices stated

F.O.B. Anaheim, California

ADM-3A
$770.00

ADM-1A
$1195.00

ADM-2
$1650.00

National Computer is a major supplier of computer terminals with offices in major cities. We offer shipment on short notice and in many cases (ADM-3A) from inventory.

NATIONAL COMPUTER
Communications Corp.
The Greatest Name in Terminals

Call **800-243-9006** TOLL FREE

IN CONN	203-325-3831	(Stamford)
NEW YORK	212-354-9866	(42nd Street)
BOSTON	617-235-7055	(Wellesley)
NEW JERSEY	201-766-4662	(Bernardsville)
CHICAGO	312-296-0830	(Des Plaines)

MAIL ORDERS TO: 26 Sixth Street, Stamford, CT 06905

Registration and Accommodations

The registration fee is $120 for individuals from EDUCOM member colleges and universities, $180 for all other participants. This fee includes the cost of the seminar notebook, related reading material, handouts, luncheon, and coffee. It does not include the cost of hotel accommodations. EDUCOM has reserved a block of rooms at hotels in each of the cities where seminars are scheduled. Anyone requiring overnight accommodations should contact the hotels directly in order to reserve a room (names and addresses are available from EDUCOM).

In order to register or obtain brochures or additional information about any of the seminars, fill out and mail the registration form on page 25 or telephone Ms. Carol Parysz at EDUCOM, 609-921-7575. Because attendance is limited to 30 participants per seminar, advance registration is encouraged.

REGISTRATION FORM

Please send me a brochure for the following seminars:

- ☐ Pricing Computing Services
- ☐ On-Line Admissions and Registration Systems
- ☐ Simulation with the Computer
- ☐ Teaching Law with the Computer

Return form to:
Ms. Carol Parysz
EDUCOM
P.O. Box 364
Princeton, N.J. 08540

Name_____ Position _____

Name_____ Position _____

Name_____ Position _____

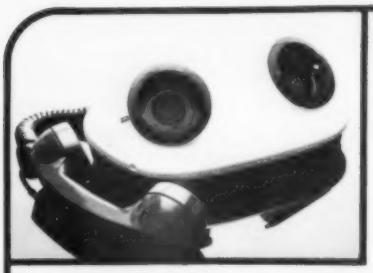
Organization _____

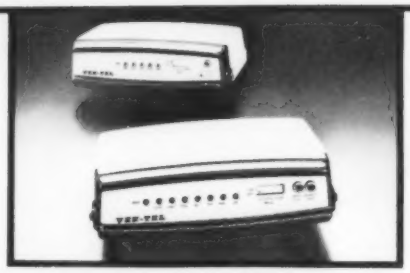
Address _____

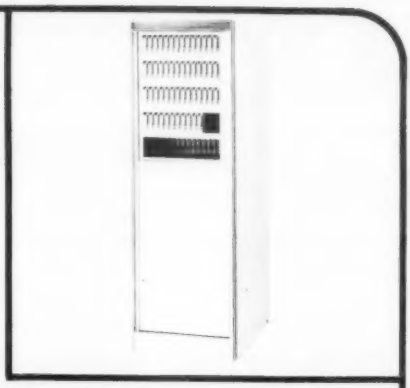
City_____ State_____ Zip_____

Telephone _____

For more information, or to reserve a place in a particular seminar, telephone Carol Parysz at EDUCOM, 609-921-7575.







Data communication products available from **VEN-TEL** offered to **EDUCOM** members for the first time at **REDUCED PRICES.**

- Acoustic Couplers
- 300 Baud — originate and Auto-Answer Modems
- 300 Baud — Lease Line Modems
- DEC LA36 EIA/Modem Kit
- 1200 Baud 202 Modems
- FDM's
- Line Drivers — 1200 bps to 50 KBS
- Interconnect Cables

Stand-alone or rack mounted configurations immediately available from shelf stock, and all are covered by a one year factory warranty.

Also available from stock is the **NEW** Model MD1212, 1200 baud, 2-wire, full duplex modem, featuring for the first time operational modes of:

- Acoustic Coupling
- Originate — Manual DAA
- Auto-Answer — CBT/CBS Compatible
- Lease Line

with standard 103/113 protocols, RS232C interface, diagnostic indicators, remote testing and more.

The Model MD1212 allows you to utilize terminal capabilities with improved operator efficiency and reduced telephone charges.

NOW, an affordable 1200/1200 full duplex modem at **REDUCED EDUCOM PRICES.**

For more information, write:

VEN-TEL 2360 Walsh Avenue Santa Clara, Ca. 95050 Telephone (408) 984-2727

FAST DELIVERY

the one source FOR YOUR DATA COMMUNICATIONS EQUIPMENT

Texas Instrument highest technology, smallest in size, lightest in weight.

Techtran- little machines, big memory Model 815 - capable of storing 140,000 characters.

ADDS - full line of CRT Terminals from glass teletype to full graphics

Westwood Associates, data communications equipment specialist for over ten years, represents the major companies in the field. Their sales engineers pride themselves in giving personal service and are capable and willing to give technical assistance. We have the expertise to customize systems to meet your specific requirements.

Westwood Associates has built a reputation for quick delivery, lowest prices, with nationwide service.

Call "the one source," and find out for yourself.

Other Products

DATA GENERAL IMPACT PRINTERS
DIABLO HIGH QUALITY PRINTERS
I.M.I. VIDEO PROJECTORS
PANASONIC BADGE READERS
FLOPPY DISCS
SCOPE DATA 120 C.P.S. PRINTERS
DECWRITERS

SPECIAL DISCOUNTS FOR EDUCATIONAL INSTITUTIONS

Westwood Associates, inc.
DATA COMMUNICATIONS EQUIPMENT
1442 Broad Street, Bloomfield, N.J. 07003
(201) 338-0200 (212) 964-3018
Philadelphia Area (609) 829-7280

Museum Data Bank Reports

The Museum Data Bank Committee has announced that the following four additional titles are now available in their series of reports: Report #9, *Computerization of Synonymy Data from Biological Systematics* by James F. Mello; Report #10, *The Onomastic Octopus* by Robert G. Chenhall; Report #11, *An Information System for History Museums* by Carole E. Rush; Report #12, *A Management Information System Design for a General Museum* by Sandra Scholtz. The Museum Data Bank Research Reports may be ordered by number from Dr. Robert G. Chenhall, Margaret Woodbury Strong Museum, 700 Allen Creek Road, Rochester, New York 14618. The cost is $1 for each report desired plus 35c per order to cover mailing costs. Make checks payable to the Museum Data Bank Committee. No credit or COD orders will be accepted. Previous reports are still available.

Computer Literacy

A two-year study of computer literacy, being conducted by the Minnesota Educational Computing Consortium (MECC) under a grant from the Education Division of the National Science Foundation, should provide valuable information regarding the ways elementary and secondary school teachers are using computers, or teaching about computers, in their classrooms. Computer literacy instructional materials and measurement instruments will be developed. Persons who are doing work in the area of computer literacy are requested to send sample course/unit descriptions, objectives, curriculum materials, and measurement instruments to the Computer Literacy Project, MECC, 2520 Broadway Drive, St. Paul, Minnesota 55113. For further information write to Dan Klassen or Tom Hansen at the above address or telephone them at 612-376-1145.

New Supplier for Lear-Siegler Terminals

National Computer Communications Corp. has signed a one-year agreement to provide Lear-Siegler terminals to EDUCOM members at prices considerably lower than those currently offered. The ADM-3A, for example, sells for $770. National Computer Communications Corp. will replace Mainland Computer Company, which chose not to renew its agreement. Anyone interested in acquiring Lear-Siegler terminals should contact Michael E. Donlon, Regional Manager, National Computer Communications Corp., 26 Sixth Street, Box 3273, Stamford, Connecticut 06905; 800-243-9006 or 203-325-3831 (leave message with Jill Saunders).

EDUCOM
Box 364, Rosedale Road
Princeton, N. J. 08540

209676

Nonprofit Org.
U.S. Postage
PAID
Harrisburg, Pa. 17101
Permit No. 1

1978 Spring Seminars

Pricing Computing Services in Colleges, Universities, and Nonprofit Organizations

Dan Bernard, EDUCOM

March 21	Philadelphia
March 30	San Francisco
April 4	St. Louis (day before the SIGUCC spring meeting)
August 7	Toronto
August 21	Dallas

On-Line Admissions and Registration Systems (cosponsored with AACRAO)

Robert W. Spencer and Erland D. Peterson, Brigham Young University

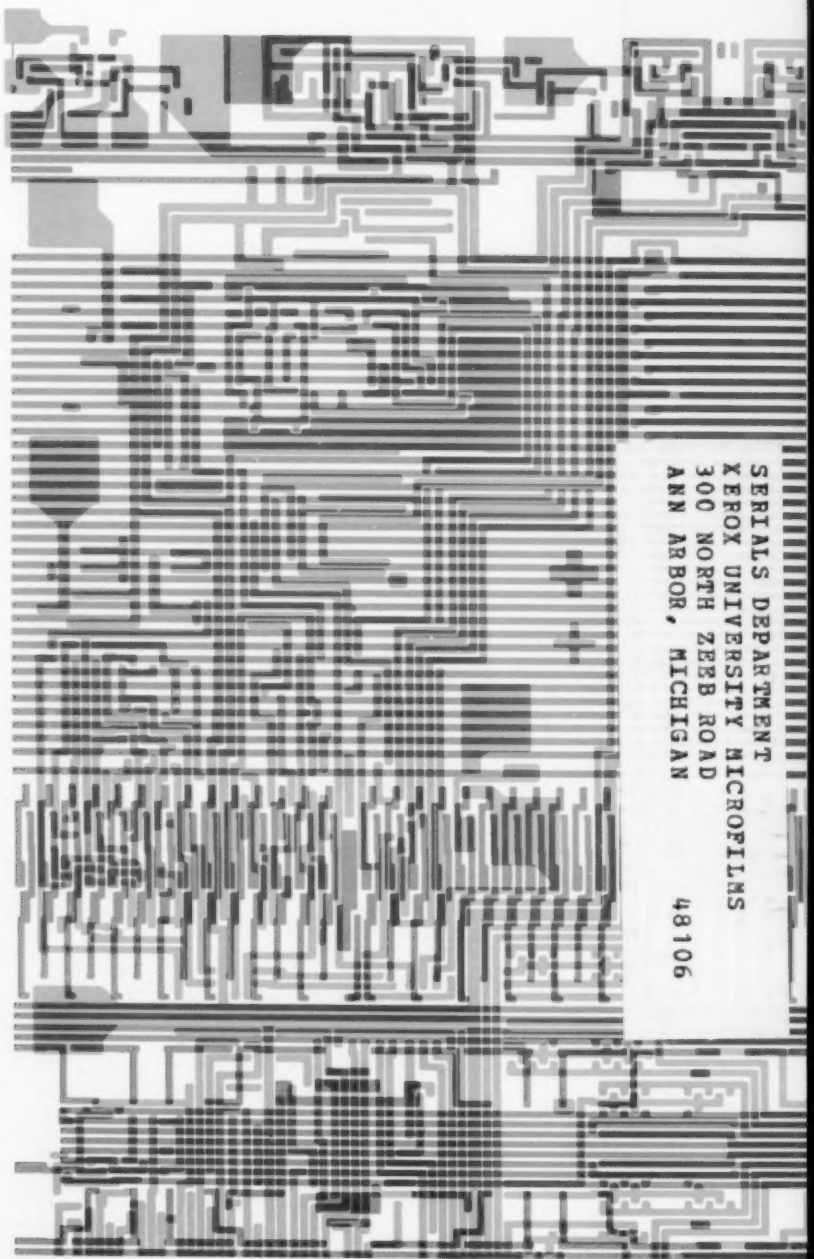
April 16	Miami (day before the AACRAO annual meeting)
May 25	Chicago
June 13	San Francisco
July 18	Toronto

Simulation with the Computer

John W. McCredie, Carnegie-Mellon University

May 10	Philadelphia
June 14	San Francisco

Teaching Law with the Computer

Russell Burris, University of Minnesota
Roger Park, University of Minnesota Law School
Robert Keeton, Harvard Law School

March 21	Philadelphia
March 29	San Francisco